OPERATOR'S
INSTRUCTION
BOOK

Cincinnati
Nos. 3, 4, 5 AND 6
HIGH POWER AND DUAL POWER DIAL TYPE MILLING MACHINES

CINCINNATI

Publication No. M-1803

This Booklet should be
Filed in the Tool Crib and
Issued by Tool Check only

THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U. S. A.

THIS book was written for operators of CINCINNATI Nos. 3, 4, 5 and 6 High Power and Dual Power Dial Type Milling Machines.

At the time of writing, the book was completely up-to-date. However, due to continual improvements in design, it is possible that descriptions contained herein may vary to a slight extent from the machine delivered to you. This merely implies that the machine has been improved to better fulfill your requirements.

* * *

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THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U. S. A.

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ILLUSTRATION REFERENCE NUMBERS

For your convenience in quickly finding illustrations referred to in the text, we have given all illustrations the same number as the page on which they appear. For example, Figures 21A, 21B and 21C are all on page 21.

◆

PATENT NOTICE

The machines and attachments illustrated and described in this book are manufactured under and protected by issued and pending United States and Foreign Patents.

* * *

The design and specifications of these machines are subject to change without notice.

◆

SERIAL NUMBER

The serial number is stamped on the face of the column and also on the front face of the table at the right-hand end. This number provides the most positive identification and should always be referred to in correspondence relating to your machine.

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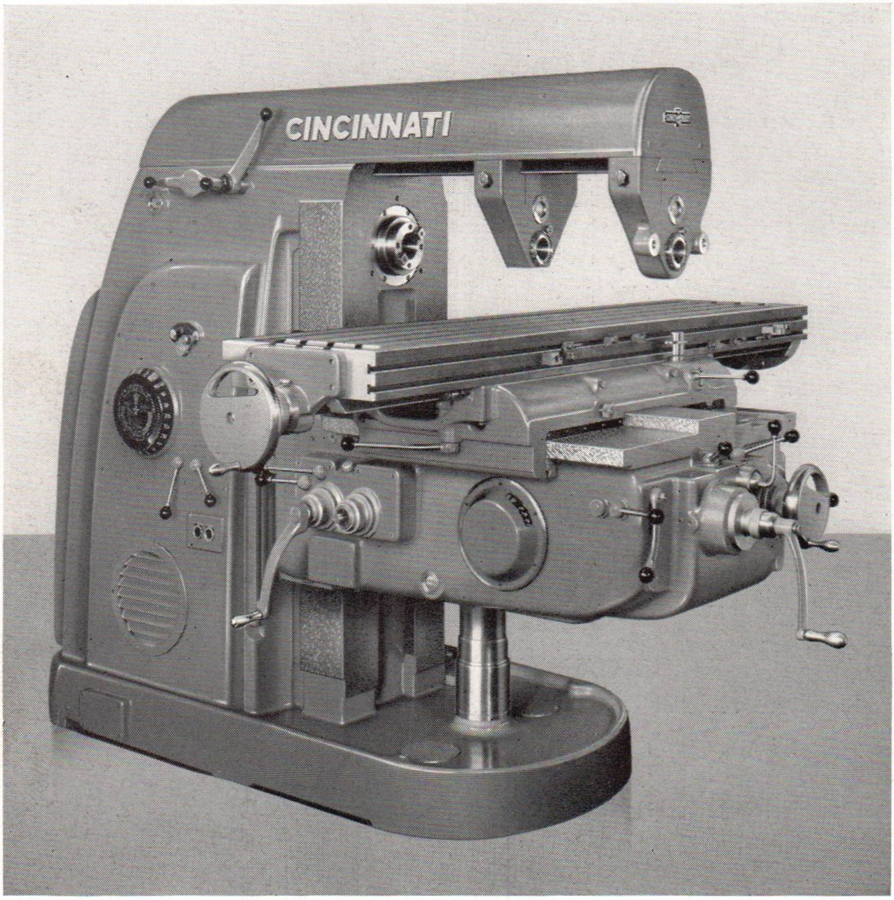


Figure 4
Cincinnati Plain Dual Power Dial Type Milling Machine

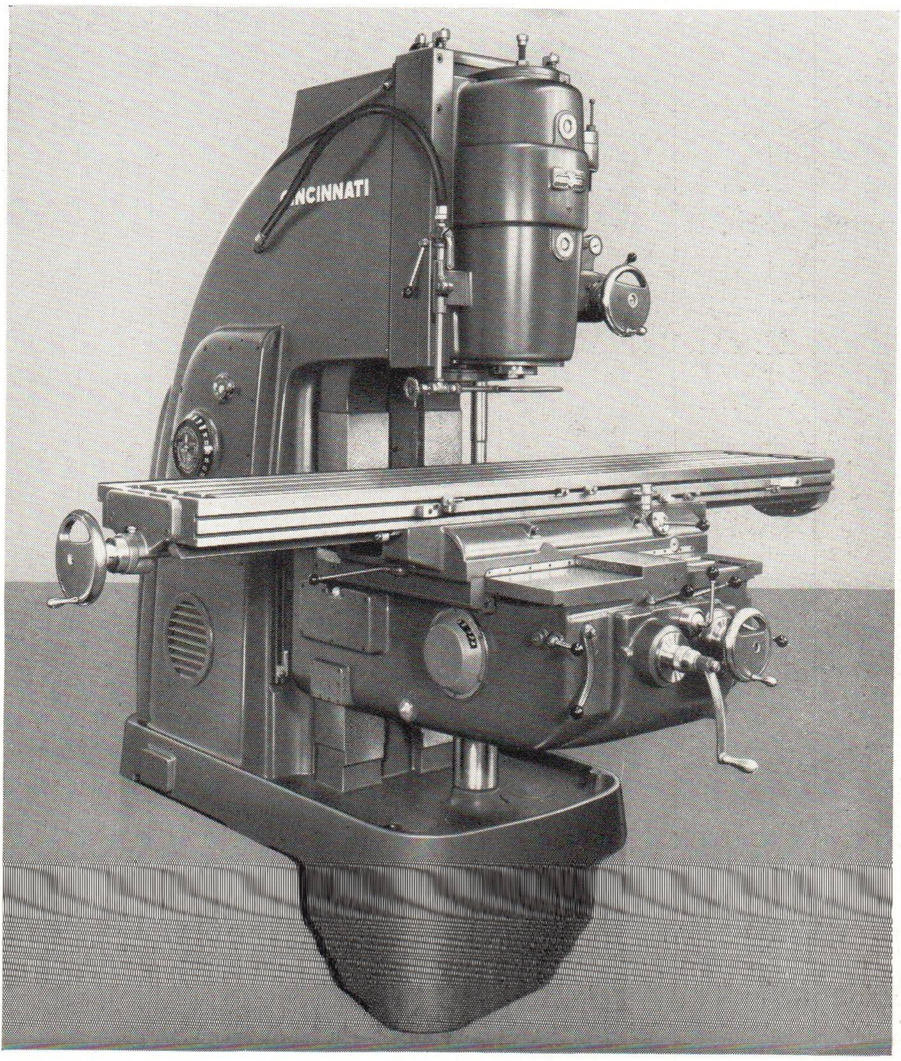


Figure 5
Cincinnati Vertical Dual Power Dial Type Milling Machine

PRINCIPAL MACHINE SPECIFICATIONS

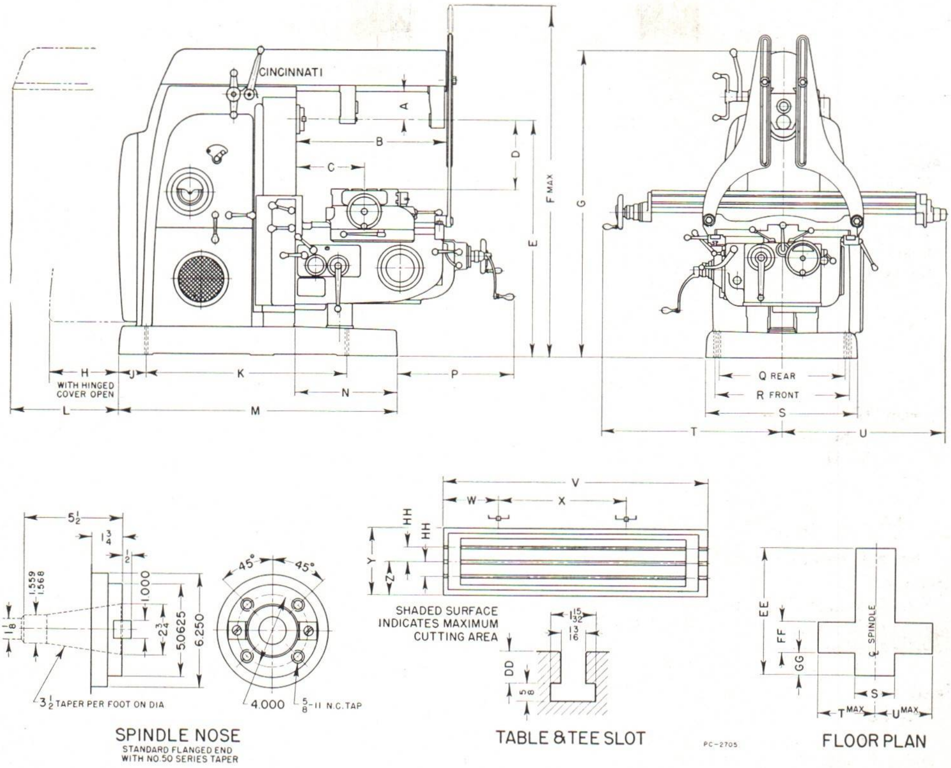
(See note at bottom of page)

	No. 3	No. 4	No. 5	No. 6
Table				
Working surface	64¾" x 16"	80" x 18"	94½" x 20"	104½" x 20"
Size over-all	64¾" x 16"	80" x 18"	94½" x 20"	104½" x 20"
T-slots, number and size	Three—13/16"	Three—13/16"	Three—13/16"	Three—13/16"
Distance between T-slots	3¼"	3¼"	4¼"	4¼"
Swivels, right and left (Universal only)	45°	45°	40°	....
Range				
Longitudinal	34"	42"	50"	60"
Cross — Plain (without brace)	12"	14"	14"	14"
Cross — Universal (without brace)	12"	14"	14"	....
Cross — Vertical	14"	16"	18"	18"
Vertical (Knee) — Plain	19"	20"	20"	20"
Vertical (Knee) — Universal	18"	19"	19"	....
Vertical (Knee) — Vertical	14"	16"	16"	16"
Vertical head movement	6"	7"	8"	8"
Spindle				
Standard milling machine spindle nose	No. 50	No. 50	No. 50	No. 50
Speeds — Number	24	24	24	24
Speeds — Range	16—1600 rpm	16—1600 rpm	14—1400 rpm	14—1400 rpm
Feeds				
Number	32	32	32	32
Range — Longitudinal	3/8"– 90" per min.	3/8"– 90" per min.	3/8"– 90" per min.	3/8"– 90" per min.
Range — Cross	3/8"– 90" per min.	3/8"– 90" per min.	3/8"– 90" per min.	3/8"– 90" per min.
Range — Vertical (Knee)	3/32"–22½" per min.	3/32"–22½" per min.	3/32"–22½" per min.	3/32"–22½" per min.
Range — Vertical head	3/16"– 45" per min.	3/16"– 45" per min.	3/16"– 45" per min.	3/16"– 45" per min.
Live Power Rapid Traverse (Spindle stopped or running)				
Longitudinal	150" per min.	150" per min.	150" per min.	150" per min.
Cross	150" per min.	150" per min.	150" per min.	150" per min.
Vertical (Knee)	37½" per min.	37½" per min.	37½" per min.	37½" per min.
Vertical head	75" per min.	75" per min.	75" per min.	75" per min.
Drive				
Motor rating — High Power	15 hp	20 hp	25 hp	25 hp
Motor rating — Dual Power	20 hp	30 hp	50 hp	50 hp
Coolant Equipment				
Capacity of Pump	4 gals. per min.	4 gals. per min.	4 gals. per min.	4 gals. per min.
Net Weight (Including motor and controls)				
High Power — Plain	9,800 lbs.	11,900 lbs.	15,300 lbs.	15,600 lbs.
High Power — Universal	10,800 lbs.	12,700 lbs.	16,300 lbs.	....
High Power — Vertical	11,600 lbs.	13,900 lbs.	17,100 lbs.	17,400 lbs.
Dual Power — Plain	10,000 lbs.	12,200 lbs.	15,600 lbs.	15,900 lbs.
Dual Power — Universal	11,000 lbs.	13,000 lbs.	....	....
Dual Power — Vertical	11,800 lbs.	14,200 lbs.	17,400 lbs.	17,700 lbs.

Note—Cincinnati High Power Dial Type Millers are built in the following sizes:
Nos. 3, 4, 5, and 6 Plain. Nos. 3, 4 and 5 Universal. Nos. 3, 4, 5, and 6 Vertical.

Cincinnati Dual Power Dial Type Millers are built in the following sizes:
Nos. 3, 4, 5, and 6 Plain. Nos. 3 and 4 Universal. Nos. 3, 4, 5, and 6 Vertical.

DIMENSIONAL DRAWINGS



SPINDLE NOSE
STANDARD FLANGED END WITH NO.50 SERIES TAPER

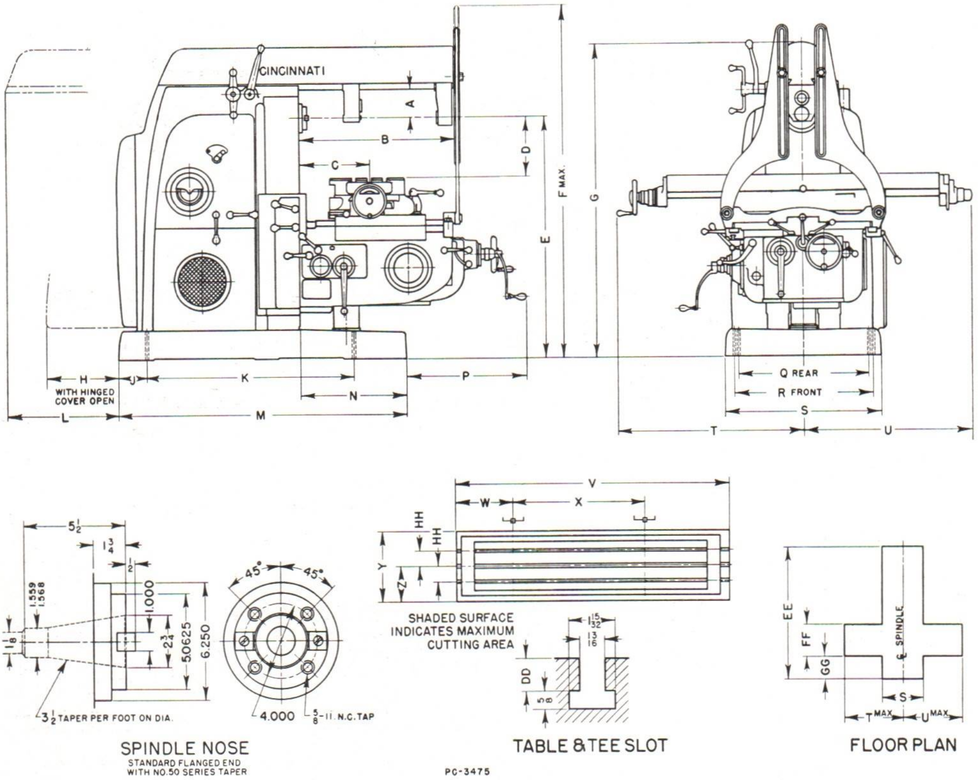
TABLE & TEE SLOT

FLOOR PLAN

Machine	A	B	C				D		E	F	G	H	J	K	L	M	N
			Without Braces		With Braces												
			Min.	Max.	Min.	Max.	Min.	Max.		Max.							
No. 3 Plain..	7 3/8	36 1/4	11	23	11	20	0	19	51 7/16	83 15/16	67 13/16	15 7/16	6 1/8	44 5/8	24 1/4	62	23
No. 4 Plain..	7 3/8	40 1/4	11 7/8	25 7/8	11 7/8	22 7/8	0	20	54 3/4	87 1/4	71 7/8	17 1/16	8 1/4	50 1/2	26 5/8	71 1/2	26 1/2
No. 5 Plain..	8 1/8	40 1/4	13	27	13	22 3/4	0	20	58 1/2	92 1/2	77 5/8	20 1/2	9 1/4	56 5/8	31	77	30
No. 6 Plain..	8 1/8	40 1/4	13	27	13	22 3/4	0	20	58 1/2	92 1/2	77 5/8	20 1/2	9 1/4	56 5/8	31	77	30

Machine	P	Q	R	S	T		U		V	W	X	Y	Z	DD	EE	FF	GG	HH
					Min.	Max.	Min.	Max.										
No. 3 Plain..	28 3/4	29 3/8	30	33 3/4	24 15/16	58 15/16	24 9/16	58 9/16	64 3/4	12 7/16	34	16	7 1/2	7/8	115	28 1/2	20 3/4	3 1/4
No. 4 Plain..	32 3/4	31 7/8	31 1/2	36	27 1/4	69 1/4	27 3/4	69 3/4	80	16 1/2	42	18	8 1/2	1	130 7/8	32 1/2	24 3/8	3 1/4
No. 5 Plain..	25 3/4	35 3/4	34 3/4	40	29 3/4	79 3/4	31 3/4	81 3/4	94 1/2	19	50	20	9 1/2	1	133 3/4	34	19 1/4	4 1/4
No. 6 Plain..	25 3/4	35 3/4	34 3/4	40	29 3/4	89 3/4	31 3/4	91 3/4	104 1/2	19	60	20	9 1/2	1	133 3/4	34	19 1/4	4 1/4

Figure 7
Dimensional Drawing
Nos. 3, 4, 5 and Plain High Power and Dual Power Machines

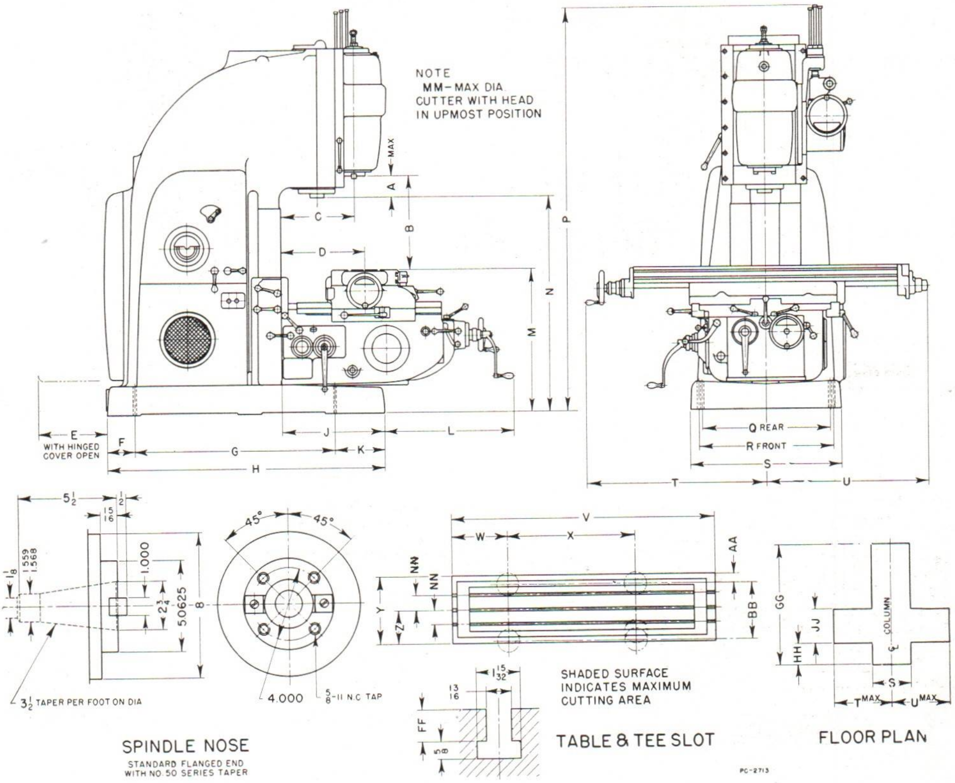


Machine	A	B	C				D		E	F	G	H	J	K	L	M	N
			Without Braces		With Braces												
			Min.	Max.	Min.	Max.	Min.	Max.		Max.							
No. 3 Univ. . .	7 3/8	36 1/4	11	23	11	20	0	18	51 7/16	83 15/16	67 13/16	15 7/16	6 1/8	44 5/8	24 1/4	62	23
No. 4 Univ. . .	7 3/8	40 1/4	11 7/8	25 7/8	11 7/8	22 7/8	0	19	54 3/4	87 1/4	71 7/8	17 1/16	8 1/4	50 1/2	26 5/8	71 1/2	26 1/2
*No. 5 Univ. . .	8 1/8	40 1/4	13	27	13	22 3/4	0	19	58 1/2	90 5/8	77 5/8	20 1/2	9 1/4	56 5/8	31	77	30

Machine	P	Q	R	S	T		U		V	W	X	Y	Z	DD	EE	FF	GG	HH
					Min.	Max.	Min.	Max.										
No. 3 Univ. . .	28 3/4	29 3/8	30	33 3/4	24 15/16	58 15/16	24 9/16	58 9/16	64 3/4	12 7/16	34	16	7 1/2	7/8	115	28 1/2	20 3/4	3 1/4
No. 4 Univ. . .	32 3/4	31 7/8	31 1/2	36	27 1/4	69 1/4	27 3/4	69 3/4	80	16 1/2	42	18	8 1/2	1	130 7/8	32 1/2	24 3/8	3 1/4
*No. 5 Univ. . .	25 3/4	35 3/4	34 3/4	40	29 3/4	79 3/4	31 3/4	81 3/4	94 1/2	19	50	20	9 1/2	1	133 3/4	34	19 1/4	4 1/4

*No. 5 Universal Machine available in High Power Series only.

Figure 8
Dimensional Drawing
Nos. 3, 4 and 5 Universal High Power Machines
Nos. 3 and 4 Universal Dual Power Machines



Machine	A	B		C	D		E	F	G	H	J	K	L	M		N	P	Q
		Min.	Max.		Min.	Max.								Min.	Max.			
No. 3 Vertical.	4 1/2	2 3/8	22 3/8	18 1/4	11	25	15 7/16	6 1/8	44 5/8	62	23	11 1/4	28 3/4	31 5/8	45 5/8	49 1/2	89 29/32	29 3/8
No. 4 Vertical.	3 3/8	0	22 3/8	20 1/2	11 7/8	27 7/8	17 1/4	8 1/4	50 1/2	71 1/2	26 1/2	12 3/4	32 3/4	33 11/16	49 11/16	52 13/16	96 25/32	31 7/8
No. 5 Vertical.	2 9/16	0	22	20 1/2	13	31	23 5/8	6 1/4	56 5/8	71	27	8 1/8	32 3/4	37 1/16	53 1/16	56 1/2	100 3/4	35 3/4
No. 6 Vertical.	2 9/16	0	22	20 1/2	13	31	23 5/8	6 1/4	56 5/8	71	27	8 1/8	32 3/4	37 1/16	53 1/16	56 1/2	100 3/4	35 3/4

Machine	R	S	T		U		V	W	X	Y	Z	AA	BB	FF	GG	HH	JJ	MM	NN
			Min.	Max.	Min.	Max.													
No. 3 Vertical.	30	33 3/4	24 15/16	58 15/16	24 9/16	58 9/16	64 3/4	12 7/16	34	16	7 1/2	1 3/4	14	7/8	106 3/16	18 3/4	30 1/2	8	3 1/4
No. 4 Vertical.	31 1/2	36	27 1/4	69 1/4	27 3/4	69 3/4	80	16 1/2	42	18	8 1/2	2 1/8	16	1	121 1/2	22 3/8	34 1/2	8 1/2	3 1/4
No. 5 Vertical.	34 3/4	40	29 3/4	79 3/4	31 3/4	81 3/4	94 1/2	19	50	20	9 1/2	0	18	1	127 3/8	19 1/4	38	9	4 1/4
No. 6 Vertical.	34 3/4	40	29 3/4	89 3/4	31 3/4	91 3/4	104 1/2	19	60	20	9 1/2	0	18	1	127 3/8	19 1/4	38	9	4 1/4

Figure 9
Dimensional Drawing
Nos. 3, 4, 5 and 6 Vertical High Power and Dual Power Machines

STANDARD EQUIPMENT SUPPLIED WITH THE MACHINE

Plain Machines

1. Two Arbor Supports, one with lugs for braces and one without lugs, both fitted with adjustable arbor bushing (2⅛" for No. 3; 2¾" for Nos. 4, 5 and 6) for Style "B" arbors.
2. Arbor Support Bushing Adapter for Style "A" arbor (including adjustable bushing, nut, washer and screw).
3. Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts AC and wired in accordance with the "Machine Tool Electrical Standards".

   Motor: Open, normal torque, low starting current, N.E.M.A. frame, ball bearing. See "Principal Machine Specifications" for hp rating.

   Controls: Full voltage magnetic starter with overload and under-voltage protection including transformer and push buttons operated at 110 volts.

   Disconnect Switch: A non-fusible type is supplied.
4. Rear Hand Adjustments and Rear Power Feed Controls—longitudinal, cross and vertical.
5. Automatic Table Cycles.
6. Automatic Backlash Eliminator.
7. Coolant Pump.
8. Overarm Braces.
9. Adjustable Arbor Tightening Rod.
10. Wrenches.
11. Standard Feed Range, ⅜" to 90" per minute.

Universal Machines

1. Standard Universal Dividing Head and Equipment, including tailstock with 2-point adjustable center and work driver; steady rest; one plate for indexing through 40 to 1 reduction—all numbers up to and including 60, all even numbers and those divisible by 5 up to 120, and many beyond; one plate for direct indexing; one center for dividing head; and provision for connecting head to enclosed driving mechanism segment.
2. Enclosed Driving Mechanism Segment, including change gears for spiral milling, leads range from 2½" to 100" (only) for Standard Universal Dividing Heads.
3. Two Arbor Supports, one with lugs for braces and one without lugs, both fitted with adjustable arbor bushing (2⅛" for No. 3, 2¾" for Nos. 4 and 5) for Style "B" arbors.
4. Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts AC and wired in accordance with the "Machine Tool Electrical Standards".

   Motor: Open, normal torque, low starting current, N.E.M.A. frame, ball bearing. See "Principal Machine Specifications" for hp rating.

   Control: Full voltage magnetic starter with overload and under-voltage protection including transformer and push buttons operated at 110 volts.

   Disconnect Switch: A non-fusible type is supplied.
5. Arbor Support Bushing Adapter for Style "A" arbors (including adjustable bushing, nut, washer, and screw).
6. Rear Hand Adjustments and Rear Power Feed Controls—longitudinal, cross and vertical.
7. Automatic Backlash Eliminator.
8. Coolant Pump.
9. Overarm Braces.
10. Adjustable Arbor Tightening Rod.
11. Wrenches.
12. Standard Feed Range, ⅜" to 90" per minute.

Vertical Machines

1. Power Feed and Power Quick Traverse to the Vertical Head.
2. Turret Stop, four-position with dial indicator.
3. Rear Power Feed Control—longitudinal only.
4. Complete Electrical Equipment for 50 or 60 cycle, 2 or 3 phase, 220 to 550 volts AC and wired in accordance with the "Machine Tool Electrical Standards".

   Motor: Open, normal torque, low starting current, N.E.M.A. frame, ball bearing. See "Principal Machine Specifications" for hp rating.

   Controls: Full voltage magnetic starter with overload and under-voltage protection including transformer and push buttons operated at 110 volts.

   Disconnect Switch: A non-fusible type is supplied.
5. Automatic Table Cycles.
6. Automatic Backlash Eliminator.
7. Coolant Pump.
8. Adjustable Arbor Tightening Rod.
9. Wrenches.
10. Standard Feed Range ⅜" to 90" per minute.

INSTALLATION INSTRUCTIONS

To obtain accurate results from a milling machine over a long period of time, three requirements must be met. First, the foundation upon which the machine sits must be heavy enough to maintain stability and flatness under the weight of the machine. Second, the machine must be firmly anchored to the foundation; and third, the machine must be carefully leveled and then checked occasionally to be sure that level is maintained.

Foundation. If the floor upon which the CINCINNATI High Power and Dual Power Dial Type Milling Machines will be located is made of substantial wood or concrete, fairly flat, and sufficiently heavy to withstand the weight of the machine, no special foundation will be required. For floors of lesser stability and strength, a suitable foundation should be prepared to insure proper machine performance.

Lifting the Machine. The plain and universal machines may be lifted by a crane with a rope or cable sling around the overarm (Figure 11A). Tighten the overarm clamping lever before lifting.

The vertical machines may be lifted by a crane with a rope or cable sling around the throat (Figure 11B). Before lifting, adjust the saddle to the front of the knee to balance the weight.

If wire cables are used to lift the machines, protect the machine surfaces with leather padding or wood blocks.

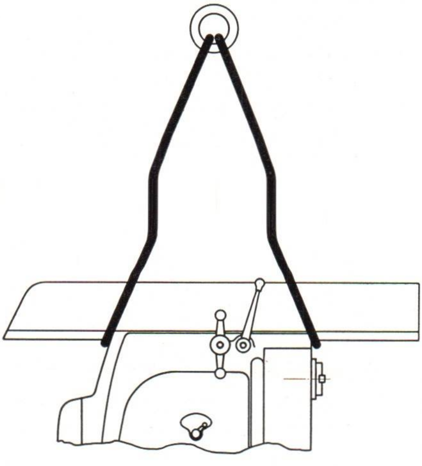


Figure 11A
Lifting the Plain and Universal Machines

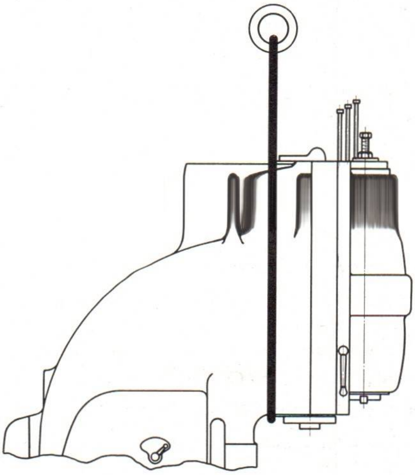


Figure 11B
Lifting the Vertical Machines

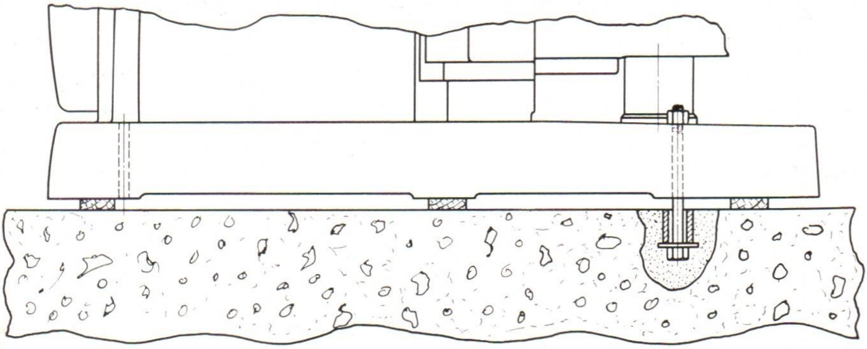


Figure 12A
Bolting the Machine to a Concrete Floor

Bolting the Machine to the Foundation. When preparing for this operation, notice that center distances of bolt holes given on the "floor plans" are approximated. If the floor is concrete, drill the bolt holes about 6″ in diameter. Insert the hold-down bolt through a 1½″ pipe, as shown in Figure 12A, and fill the pipe with dry sand. Lower the machine onto two 1″ thick boards, and engage the nuts on two or three threads of the bolts. Fill the holes around the pipes with quick drying cement, thin enough to flow easily. When the cement is dry, remove the boards, level machine, and tighten hold-down nuts.

Leveling. After the machine has been moved to its proper location, it must be accurately leveled. Use an accurate micrometer level for the operation. A carpenter's level or the bulb in a machinist's combination square is not good enough. Drive steel wedges (Figure 12B) under the corners of the base until the table is level in both directions. Then drive additional wedges under the base to evenly distribute the weight of the machine, and recheck for level. It is necessary, of course, that the machine table and leveling instrument be absolutely clean and free from burrs to obtain the most accurate results.

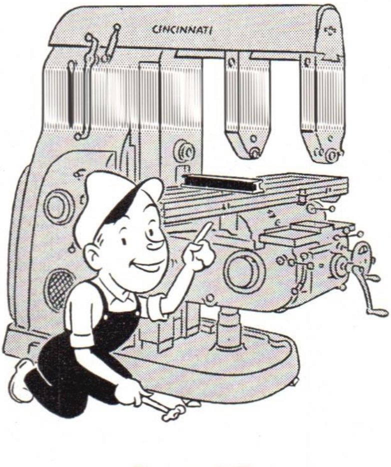


Figure 12B
Leveling the Machine

Assembling Table to Machine—(**With Backlash Eliminator**). If the machine table and leadscrew have been removed for convenience in shipping and machine is equipped with a backlash eliminator, the following instructions must be adhered to when reassembling machine table and leadscrew.

Important. Never remove the backlash eliminator housing and do not move steel nuts on bronze leadscrew nuts in relation to each other. Backlash eliminator disengaging knob should be in disengaged position (see page 27) before assembling table to machine.

1. Remove wire which holds two backlash eliminator nuts in housing. Remove one bronze leadscrew nut at a time, clean and replace.
2. Push in right-hand nut (as viewed from front of machine) and align inscribed line on nut with line on housing by turning nut against spring tension. Insert leadscrew from right-hand end of machine. Make sure nut is held tight against housing and also that scribed lines are kept aligned while inserting leadscrew. Turn leadscrew until its end is just through right-hand nut.
3. Push in left-hand nut and align scribed line on nut with line on housing. Turn leadscrew into left-hand nut. *Make sure that both nuts are held tight against housing and also that scribed lines on both nuts are kept aligned with lines on housing.* Turn leadscrew in far enough so that it passes completely through left-hand nut.
4. Wash bearing surfaces on the saddle and table perfectly clean. Apply a liberal coat of machine oil to saddle bearings.
5. Place table control lever in its neutral or middle position.
6. Insert two table locking shoes in holes in front of saddle and follow up with table clamping screws.
7. Insert table from the left-hand side of machine.
8. Insert table gib between saddle and table and adjust gib (see page 42).
9. Turn leadscrew in until apron on right-hand end of leadscrew is tight against right-hand end of table. Be sure dowel pins in apron match with pin holes in end of table. Insert and tighten apron screws.
10. Attach left-hand apron to left-hand end of table. Adjust the adjusting nut on right-hand end of leadscrew to take up end play in leadscrew. There should not be more than .005″ backlash in leadscrew dial. Tighten lock screw in adjusting nut.

11. Place clutch, dial, spring, ball crank, etc. on left-hand end of leadscrew. Check table movement by turning hand crank. If too tight or too loose, re-adjust gib.

Assembling Table to Machine (Without Backlash Eliminator). If machine table and leadscrew has been removed for convenience in shipping, it may be replaced as follows:

1. Wash bearing surfaces on saddle and table perfectly clean. Apply a liberal coat of oil to saddle bearings.
2. Place table control lever in its neutral or middle position.
3. Insert two table locking shoes in holes in front of saddle and follow up with table clamping screws.
4. Insert table from left side, as you stand in front of machine.
5. Insert table gib between saddle and table and adjust gib (see page 42).
6. Insert table lead screw from right-hand side of machine, and turn screw into nut until apron on lead screw is tight against table. Be sure dowel pins in apron match with pin holes in end of table. Insert and tighten the four screws.
7. Attach left-hand apron to left end of table. Adjust the adjusting nut on lead screw to take up end play in lead screw Tighten hexagon head lock screw in adjusting nut.
8. Place clutch, dial, spring, ball crank, etc. on end of lead screw

Assembling the V-Belts to the Motor. Before assembling the V-belts to the motor, turn it over by hand a few times to be sure that it rotates freely, and that no objects have fallen into the motor during shipment or while it was being unpacked.

Counterweight (Vertical Machines). The sliding head of a vertical machine is balanced by a counterweight inside the machine column. The counterweight is held in position during shipment, by two screws, one on each side of the column directly above the name CINCINNATI. Remove the screws and plug the holes with the plugs provided.

LUBRICATION

After the machine has been installed in accordance with the information given in the "Installation Instructions" and the data sheet which accompany the machine, it must be thoroughly lubricated before being placed in operation.

Do not start the machine until all stations have been filled with the proper amounts of correct lubricants, as shown in the "Lubrication Instructions and Specifications", pages 16 to 18.

When the machine is running make sure that all reservoirs are full. Also, check to make sure that oil is visible in each of the oil flow gages—see page 16 for location of flow gage for horizontal machines and page 18 for vertical machines. If the oil is not visible, immediately stop the machine and check the reservoir and system.

If the machine is located in an extremely dusty atmosphere, as sometimes found near cutter sharpening machines, the table dovetail, knee-column bearing, saddle-knee bearing, and vertical head-column bearing (Vertical Machines only), should be wiped clean twice a day. After cleaning, apply oil to the bearing surfaces.

The table-saddle bearing and the saddle-knee bearing are automatically lubricated from an oil-shot system which is activated by movements of either the table control lever or the cross feed control lever. Each reversal of the table or saddle movements actuates a pump to provide a shot of oil to the bearing ways.

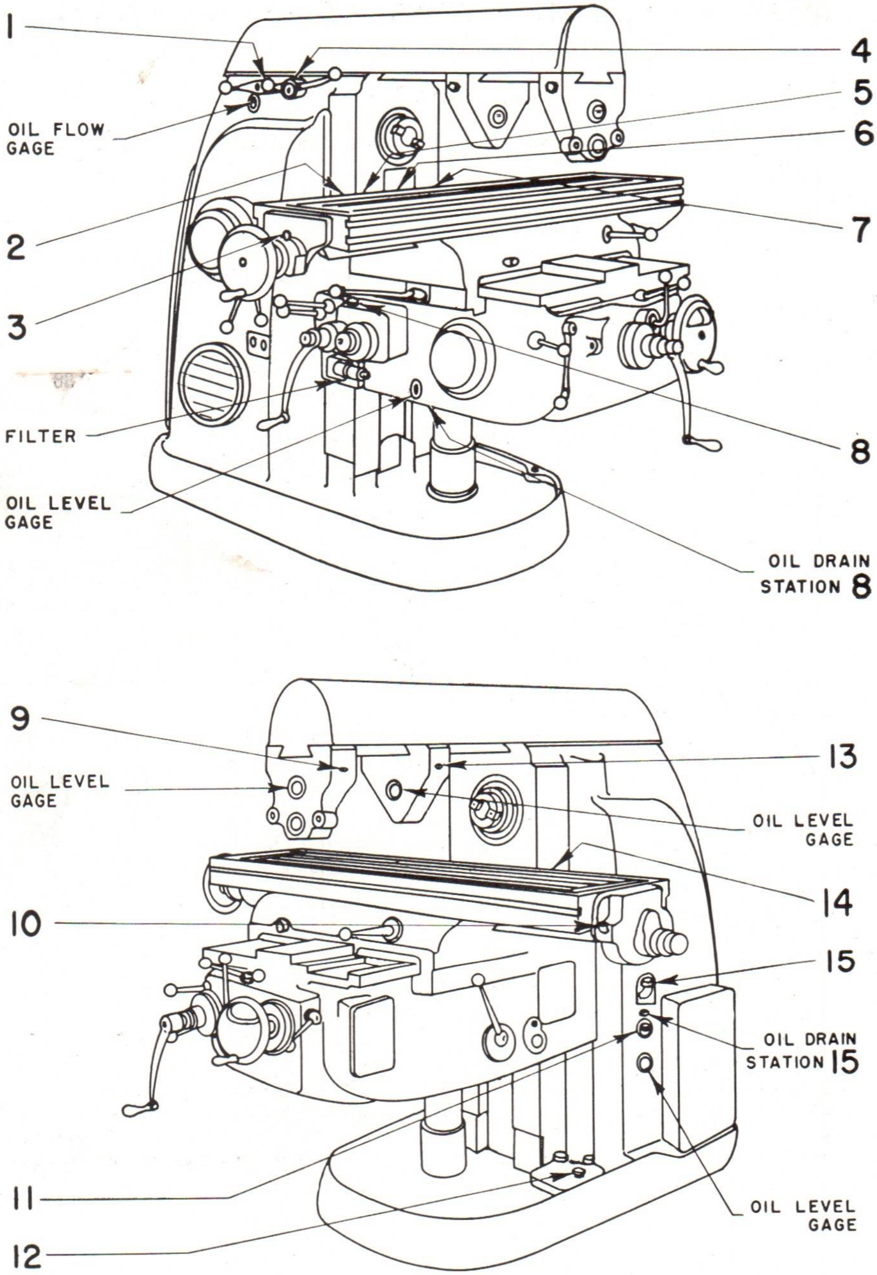


Figure 16
Lubrication Diagram

LUBRICATION INSTRUCTIONS AND SPECIFICATIONS

See Page 18 for Lubrication of Vertical Head

When to Oil	Station Numbers	Instructions	Parts Lubricated	Specifications
Daily	1, 2, 3, 4, 5, 6, 7, 10 and 14	Oil with a bench oiler	Column-knee bearing, overarm crank, etc.	P-55 Mineral oil. Viscosity 200-220 seconds Saybolt at 100° F.
Check Daily	12	Keep filled to level of opening. Use oil pot to fill.	Coolant pump	
Check Daily	15	Keep filled to level of opening. Drain and refill every 6 months. If available, use hand pump to fill.	Column parts	P-[illegible] High quality rust and oxidation inhibited, light oil. Viscosity 148 to 155 S. U. S. at 100° F.
Low Limit	11	Keep filled above low limit on gage. Use oil pot to fill.	Vertical screw	P-53 Good quality light oil, Viscosity 155 to 165 S. U. S. at 100° F.
Low Limit	9 and 13	Keep filled above low limit on gage. Use oil pot to fill.	Arbor bearing collar	P-55 (see above).
†Six Months	8	Keep filled above low limit in gage. Drain and refill every 6 months.* If available use hand pump to fill.	Knee parts, saddle-knee bearings, saddle-table bearings.	

*If machine is run continually 24 hours a day, change the oil every 2 months.

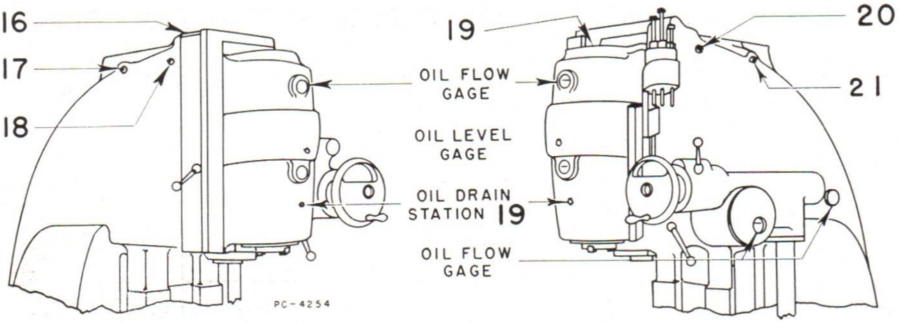
Stations 2, 5, 6, 7, and 14 are located at top of knee near column.

Drain for Station 8 located on bottom of knee.

Lubrication instructions for dividing head are given on page 55.

P-40, P-49 and P-55 are The Cincinnati Milling Machine Co.'s specification numbers.

†The filter, located on left-hand side of knee (see Figure 16), should be changed every two months. It is a Skinner Purifier Element No. AN 6235-3, Part No. 28025-AH. Simply unscrew the cylindrical housing, remove the filtering element and replace with the new element.



Instructions for Parts of Vertical Machine not shown are same as Horizontal Machine (Pages 16-17)

Figure 18—Lubrication Diagram

LUBRICATION INSTRUCTIONS AND SPECIFICATIONS
(Vertical Machines Only)

When to Oil	Station Numbers	Instructions	Parts Lubricated	Specifications
Daily	16	Oil with a bench oiler	Sliding ways for vertical head	P-55 Mineral oil. Viscosity 200-220 seconds Saybolt at 100° F.
Monthly	17, 18, 20 and 21	Apply two or three shots with a grease gun	Counterweight chain	P-37 Medium quality cup grease, free of acid and fillers.
Low Limit	19	Keep filled above low limit on gage. Drain and refill every 6 months. Use oil pot to fill.	Vertical head parts	P-55 (see above).

P-37 and P-55 are The Cincinnati Milling Machine Co.'s specification numbers.

STARTING THE MACHINE FOR THE FIRST TIME

After the machine has been properly installed and lubricated, and the slushing oil washed off, it is ready to start.

Momentarily start the motor and immediately notice the direction of rotation of the driven pulley at the rear of the machine. To start the motor with the compartment door open, you must hold the safety switch button in contact by hand (Figure 19B), while someone starts and quickly stops the motor by means of the push buttons. The pulley must rotate counter-clockwise as indicated by the direction plate (Figure 19A) attached to the driven pulley.

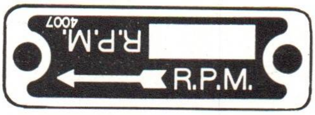


Figure 19A
Pulley Must Rotate
Counter-Clockwise
When Viewed From
Rear of Machine

Run the machine for a half hour or so to insure a protective film of oil over all the bearings, and apply oil frequently during this period. Do not fill the reservoirs while the machine is running.

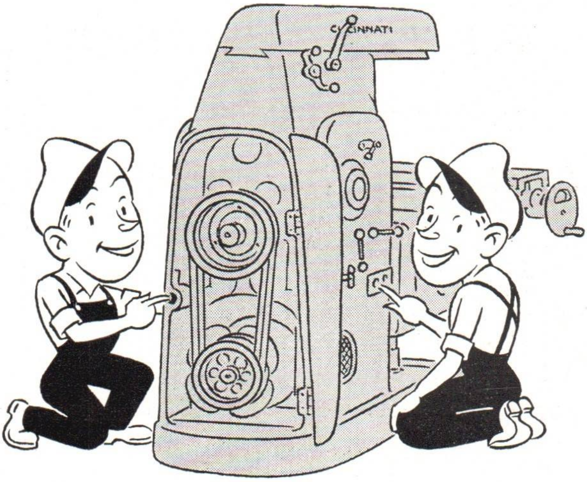


Figure 19B
Starting the Motor with the
Motor Compartment
Door Open

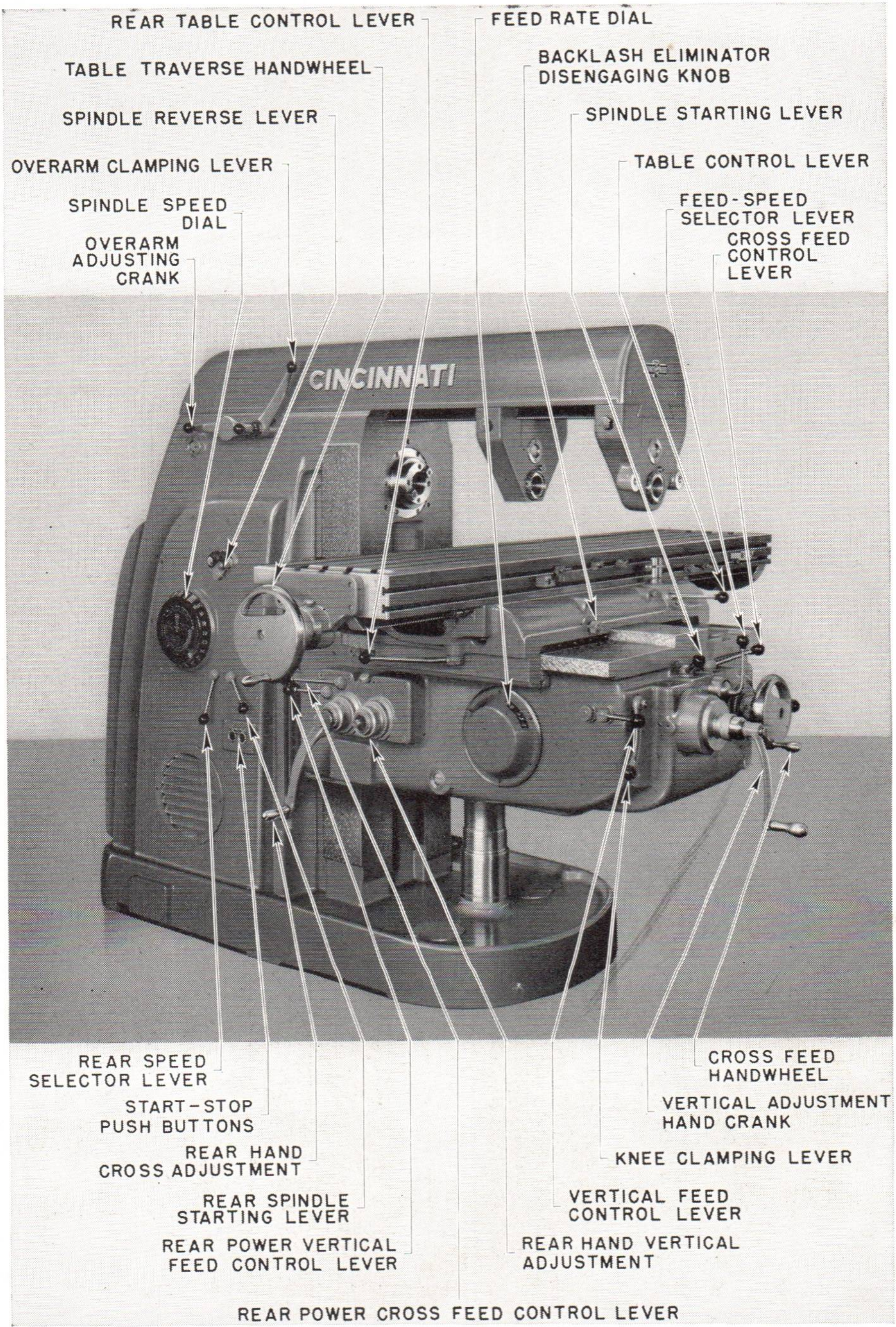

REAR TABLE CONTROL LEVER
TABLE TRAVERSE HANDWHEEL
SPINDLE REVERSE LEVER
OVERARM CLAMPING LEVER
SPINDLE SPEED DIAL
OVERARM ADJUSTING CRANK
FEED RATE DIAL
BACKLASH ELIMINATOR DISENGAGING KNOB
SPINDLE STARTING LEVER
TABLE CONTROL LEVER
FEED-SPEED SELECTOR LEVER
CROSS FEED CONTROL LEVER
CINCINNATI
REAR SPEED SELECTOR LEVER
START-STOP PUSH BUTTONS
REAR HAND CROSS ADJUSTMENT
REAR SPINDLE STARTING LEVER
REAR POWER VERTICAL FEED CONTROL LEVER
REAR POWER CROSS FEED CONTROL LEVER
CROSS FEED HANDWHEEL
VERTICAL ADJUSTMENT HAND CRANK
KNEE CLAMPING LEVER
VERTICAL FEED CONTROL LEVER
REAR HAND VERTICAL ADJUSTMENT

Figure 20
Functional Diagram

OPERATING INSTRUCTIONS

In general, these instructions apply to plain, universal, and vertical machines. See pages 35 and 36 for instructions which apply to vertical machines only.

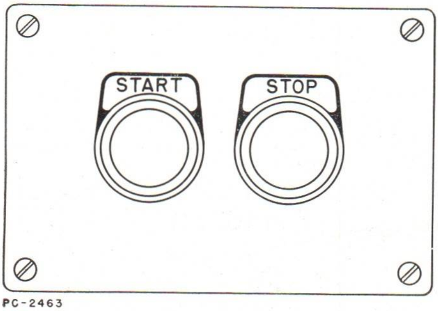


Figure 21A
Start-Stop Buttons

Starting the Machine. Place all directional feed control levers in their neutral or stop positions as shown in Figures 25A, 25B, and 26. Make sure the hinged motor compartment door at the rear of the machine is closed or the machine will not start. Move the spindle reverse lever (Figure 20) to its right or left position, depending upon the direction of spindle rotation desired. To start the motor, press the "START" button shown in Figure 20. To start the spindle rotation move the spindle starting lever to the right (Figure 21B). A spindle starting lever is also provided at the rear operating position (Figure 21C) as standard equipment for all three styles of machines—Plain, Universal and Vertical. A quick acting brake automatically stops the spindle when either one of the starting levers is moved to the stop position. To stop the motor, press the "STOP" button (Figure 20).

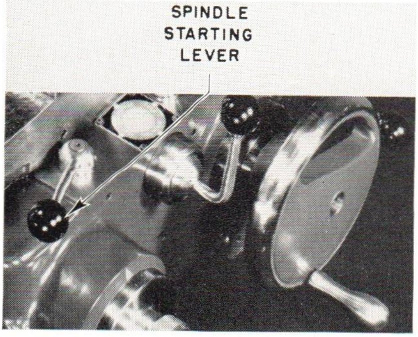


Figure 21B
Front Spindle Starting Lever

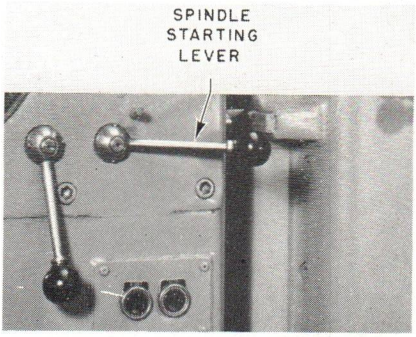


Figure 21C
Rear Spindle Starting Lever

Changing Speeds and Feeds. Start the motor and make sure the spindle starting levers are in their stop positions. All three styles of High Power and Dual Power Millers are provided with speed and feed selector control levers for both the front and rear operating positions.

When working at the front of the machine, a single lever (Figure 22A) controls both the speed and feed changes. To increase the speed move the lever to its upper left position; to decrease the speed move the lever to its lower left position. Moving the lever to the upper right position increases the feed, while moving it to the lower right position decreases the feed. Speed rates are indicated on the spindle speed dial, feed rates are indicated on the feed rate dial (Figure 20).

Separate feed and speed selector control levers are provided at the rear working position (Figure 22B). Shift the speed selector lever to the right to increase speeds, to the left to decrease speeds. Shift the feed selector lever upward to increase the feed rates, downward to decrease them.

For operating convenience a milling speed calculator is mounted inside the speed dial (Figure 20) and is supplied as standard equipment. Complete operating instructions for determining cut speed and cutter rpm are given on the calculator.

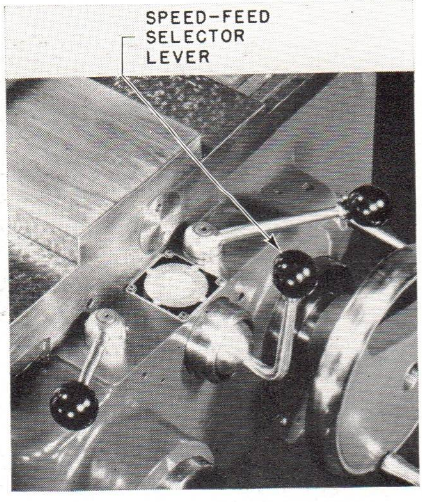


Figure 22A
Front Speed-Feed Control Lever

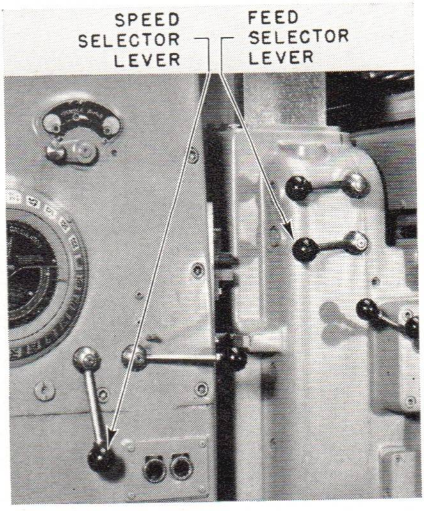


Figure 22B
Rear Speed-Feed Control Levers

Micrometer Dials. All of the hand controls, longitudinal, cross, and vertical, are provided with adjustable micrometer dials. To reset, or "zero", one of these dials, pull it outward against light spring pressure, rotate to the desired position and release.

Hand Table Feed. The table can be moved longitudinally by hand, when power is disengaged, by turning the table traverse handwheel (Figure 23A). When the handwheel is rotated one turn in a clockwise direction the table moves to the right ¼ inch. The dial is graduated into 250 equal spaces, each of which is equivalent to .001″ movement. To use the hand table traverse, push the handwheel "inward", toward the table, until you feel the clutch teeth mesh. A spring automatically disengages the clutch when handwheel is released. Before moving the table make certain the table clamping screws (Figure 28B) are loose.

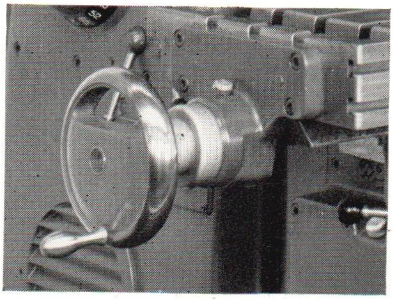


Figure 23A
Table Traverse Handwheel

Hand Cross Feed. The saddle can be moved transversely, by hand, when power feed is disengaged, by turning the cross traverse handwheel (see Figures 20 and 23B).

One clockwise turn of the handwheel moves the saddle ¼ inch toward the column. The micrometer dial is graduated into 250 spaces, each of which is equivalent to .001″ movement. To use the hand cross traverse, push the handwheel "inward" until you feel the clutch teeth mesh. The clutch is automatically disengaged when the power cross feed lever is moved to a feed position. Make certain the saddle clamping lever (Figure 28B) is unclamped before moving the saddle.

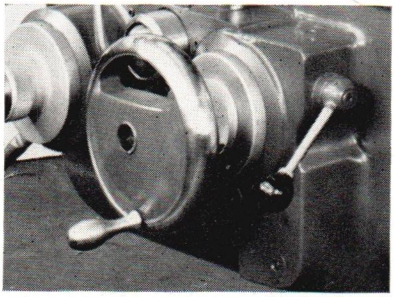


Figure 23B
Cross Traverse Handwheel

Hand Vertical Feed. The knee can be moved vertically, by hand, when power feed is disengaged, by turning the vertical adjustment hand crank (Figure 24A). One clockwise turn of the crank raises the knee .065″. The dial is graduated into 130 equal spaces, each of which is equivalent to .0005″ knee movement. To use the hand vertical traverse, push the crank "inward" until you feel the clutch teeth mesh. The clutch is automatically disengaged when the power vertical feed lever is moved to a feed position. Before moving the knee make certain the knee clamping lever (Figure 28B) is unclamped.

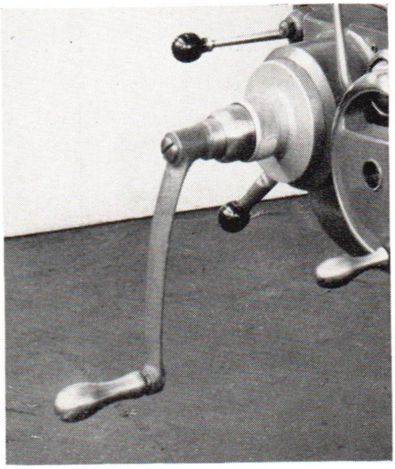


Figure 24A
Vertical Adjustment Hand Crank

Rear Hand Controls. Standard equipment for the Plain and Universal Machines includes rear hand adjustments for the cross and vertical movements, in addition to the table traverse handwheel which also can be operated from the rear. These controls, adjusted by means of a hand crank, easily moved from one shaft to the other, are shown in Figure 24B. The cross traverse dial is graduated into 250 equal spaces, each of which is equal to .001″ movement, while the vertical traverse dial is graduated into 130 spaces with each space being equal to .0005″ movement.

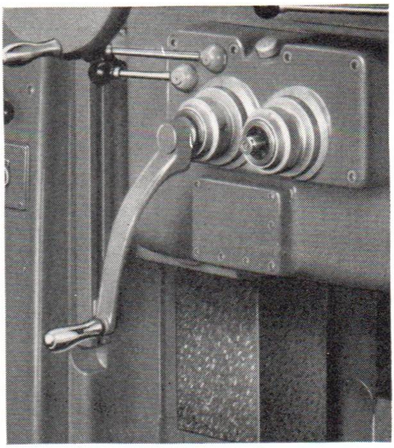


Figure 24B
Rear Hand Controls

Power Feed Controls. All power feed control levers—longitudinal, cross, and vertical—are of the directional control type, i. e., the sliding unit moves in the direction in which the lever is moved. For instance, if the table power feed lever is moved to the left, the table moves to the left; if the lever is moved to the right, the table is moved to the right.

Note—The Plain and Universal Machines are equipped with complete rear power feed controls. See "Rear Power Feed Controls", pages 27 and 28.

Power Table Feed (Plain and Vertical Machines). Longitudinal power movements of the table are engaged from the front of the machine by means of the table control lever (Figures 20 and 25A). As can be seen in Figure 25A, there are four operating positions besides neutral or stop position. To feed the table left, move the lever to its lower left position; to feed it right, move the lever to the lower right position. Rapid traverse left is obtained by moving the lever to the upper left position while rapid traverse right is obtained by moving the lever to the upper right position. Be certain that you loosen the table clamping screws before engaging the table feed or rapid traverse. It is also advisable to tighten the saddle and knee clamps when using the table feed alone. See "Clamping Devices for Sliding Units", page 28.

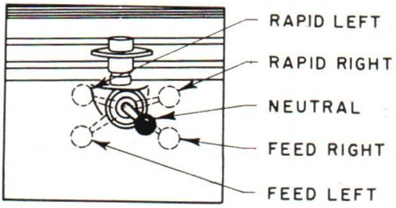


Figure 25A
Table Control Lever
(**Plain and Vertical**)

Power Table Feed (Universal Machines Only). Longitudinal power feed movements of the table are engaged from the front of the machine by means of the table control lever (Figures 20 and 25B). To feed the table left, move the lever to the left; to feed the table right, move the lever to the right. Power rapid traverse is obtained by first engaging the power table feed and then engaging the rapid traverse lever (Figure 26). Be certain that you loosen the table clamping screws before engaging the table feed or rapid traverse. It is also advisable to tighten the saddle and knee clamp when using the table feed alone. See "Clamping Devices for Sliding Units", page 28.

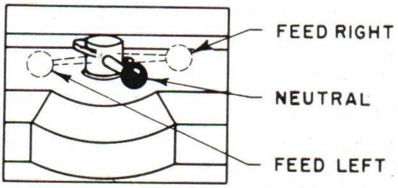


Figure 25B
Table Control Lever
(**Universal Only**)

Power Cross Feed. Transverse power feed movements of the saddle are engaged by means of the cross feed control lever (Figures 20 and 26). To feed to the rear, shift lever to the rear, to feed to the front, shift lever to front. Before engaging the cross feed, loosen the saddle clamp. It is also advisable to tighten the table clamping screws and knee clamp when using the cross feed. See "Clamping Devices for Sliding Units", page 28.

Power Vertical Feed. Vertical power feed movements of the knee are engaged by means of the vertical feed control lever (Figures 20 and 26). Shift the lever upward to raise the knee, downward to lower the knee. Before engaging the vertical feed loosen the knee clamp. It is also advisable to tighten the table clamping screws and saddle clamp when using the vertical feed alone. See "Clamping Devices for Sliding Units", page 28. Power vertical feed rates are ¼ the rates shown on the feed dial.

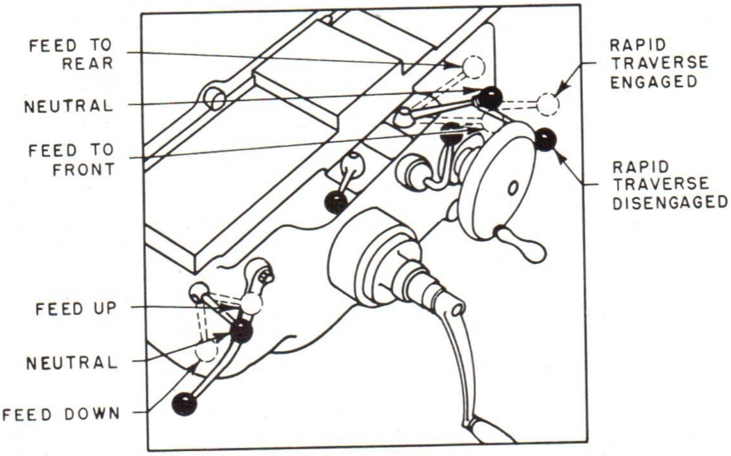


Figure 26
Transverse and Vertical Feed and Rapid Traverse Controls

Power Rapid Traverse. Power rapid traverse can be engaged at any time for any direction of travel with the spindle running or stopped. Of course, the motor must be running.

On Plain and Vertical Machines the table rapid traverse is controlled by the table control lever shown in Figure 25A. Changing from feed to rapid traverse merely requires moving the lever from its lower (feed) position to its upper (rapid traverse) position. This can be done either by hand or by trip-out dogs.

On Universal Machines power rapid traverse to the table is obtained by first engaging the table feed lever (Figure 25B) and then pulling up the rapid traverse lever (Figure 26).

To engage the cross or vertical rapid traverse on all three styles of machines—Plain, Universal and Vertical—first move the feed lever in the direction of travel desired. Then pull up the rapid traverse lever (Figure 26) to its engaged position. The sequence of engaging the levers is an important consideration in the long life of the rapid traverse clutch—always engage the feed lever first and then the rapid traverse lever. When the rapid traverse lever is released, it will return to the disengaged position.

The rapid traverse can also be engaged from the rear working position (Figure 28A). Rear rapid traverse control is provided for all three machine styles—Plain, Universal and Vertical.

The rapid traverse rate for the longitudinal and cross movements is 150 inches per minute, while the vertical rapid traverse rate is 37½ inches per minute.

Automatic Backlash Eliminator. An integral part of the table drive mechanism is a device which *automatically* eliminates the backlash between the leadscrew and the nuts *during down-milling cuts only*. The mechanism is activated by forces set up when the cutter contacts the workpiece in a down milling cut; it does not function during conventional up-milling cuts, or during rapid traverse movements of the table.

A disengaging knob is provided on the front of the saddle (Figure 20), to permit complete disengagement when the table is to be moved by means of the table feed handwheel. Since the device works automatically, and only when needed, it should be left engaged at all other times. To disengage the mechanism, turn the disengaging knob counterclockwise as far as it will go. To reengage, turn the disengaging knob clockwise as far as it will go.

Rear Power Feed Controls. Standard equipment for the Plain and Universal Machines includes complete power feed controls for operating the machine at the rear working position (Figure 28A).

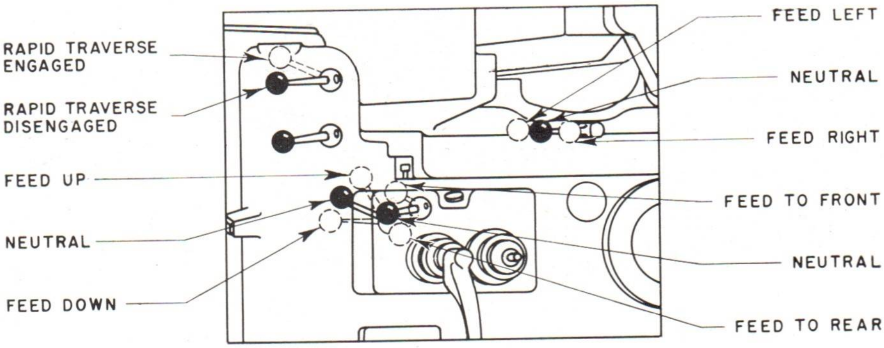


Figure 28A
Rear Power Feed Controls on Plain and Universal Machines

Unlike the front table control lever, the rear table control lever has only two operating position—feed left or feed right. Table rapid traverse is obtained by moving the table feed lever to the right or left, depending upon the direction of travel desired, and then engaging the rapid traverse lever.

Both cross and vertical power levers are provided and, like the table, cross and vertical rapid traverse can be obtained by moving the feed lever to a feed position and then engaging the rear rapid traverse lever.

Clamping Devices for Sliding Units. The table, knee, saddle and housing may be clamped in position by tightening the screws and levers shown in Figures 28B and 29. Two screws are provided for clamping the table to the saddle, one lever for clamping the saddle to the knee, one lever for

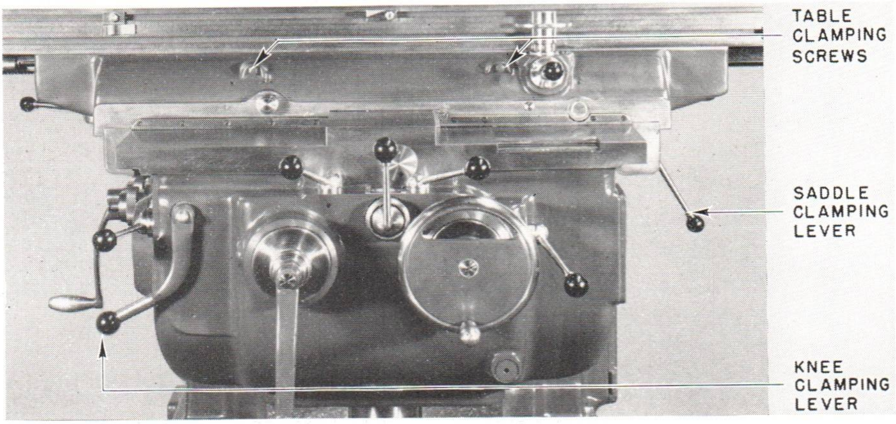


Figure 28B
Clamping Devices for Knee, Saddle and Table

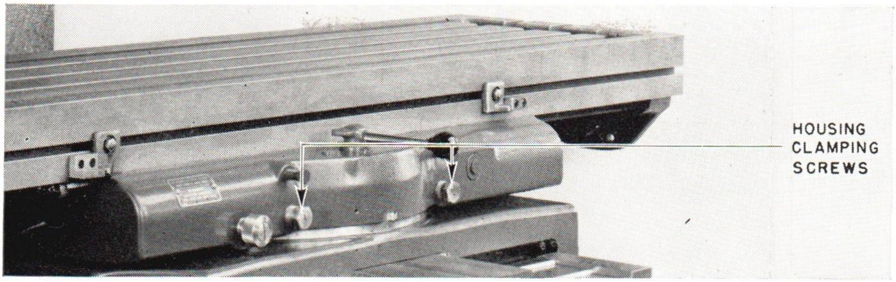


Figure 29
Housing Clamping Screws on Universal Machine

clamping the knee to the column, and four screws (two at front of housing, Figure 29, and two at rear) for clamping the housing to the saddle of universal machines. The sole purpose of these screws and levers is to firmly tighten the units which are not in motion during the machining operation. For example, if you are using the table feed alone, tighten the saddle, housing and knee clamping devices. The rigidity of the machine as a whole will thereby be increased.

These clamping devices should never be used as a method of adjustment for wear. Obviously, such a practice would result in rapid wear in the spots at which the pressure from the clamps is applied, and there is also a greater possibility of the bearings scoring, because of the concentrated pressures. Tapered gibs are provided for adjustment to compensate for wear (see "Adjusting the Gibs", page 41).

Table Trip Dogs (Plain and Vertical Machines). In addition to the use of the table control lever, power feed and rapid traverse movements can be controlled by means of trip dogs, carried in tee-slots in the front face of the table (Figure 30), on Plain and Vertical machines. A wide variety of automatic table working cycles (pages 37 to 40) can be obtained by properly positioning these dogs. Automatic table working cycles are not available for Universal machines but they are provided with table dogs to trip the table out of feed in either direction.

Eight dogs, of five different types, are supplied to control the automatic table working cycles:

2 Feed dogs.
2 Rapid traverse dogs
2 Reverse dogs.
1 End stop dog.
1 Center safety stop dog.

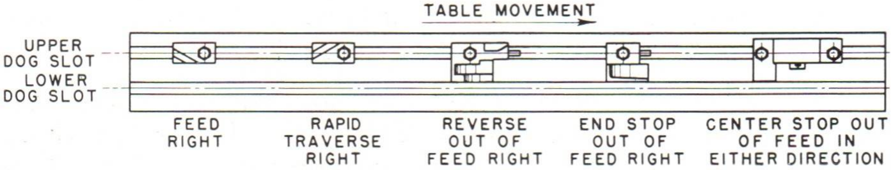
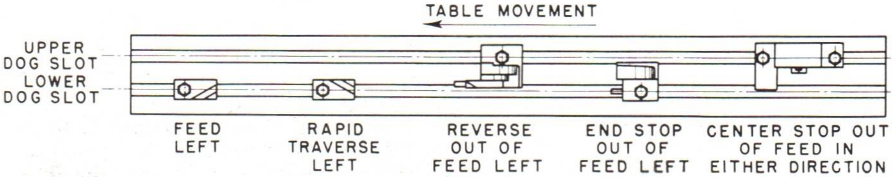


TABLE MOVEMENT
UPPER DOG SLOT
LOWER DOG SLOT
FEED RIGHT
RAPID TRAVERSE RIGHT
REVERSE OUT OF FEED RIGHT
END STOP OUT OF FEED RIGHT
CENTER STOP OUT OF FEED IN EITHER DIRECTION

Dogs Which Act When Table is Moving to the Right



Dogs Which Act When Table is Moving to the Left

Figure 30
Functions of Table Trip Dogs

The rapid traverse dogs and the feed dogs are of the same type, their function being merely to raise or lower the dog trip plunger. The upper position of the trip plunger selects the feed rate, the lower position selects the rapid traverse rate. Four of these dogs are supplied; two right-hand dogs and two left-hand dogs. These dogs are used in the upper dog slot to control table movements to the right, in the lower slot to control table movements to the left.

The reverse dogs automatically reverse the table from feed to rapid traverse in the opposite direction. One left-hand dog and one right-hand dog are supplied, both of which mount in the upper dog slot. The left-hand dog reverses the table out of feed to the right, the right-hand dog reverses the table out of feed to the left.

The end stop dog can be used to stop the table out of feed in either direction. When mounted in the upper dog slot it is used to stop the table when it is feeding to the right, when mounted in the lower dog slot it stops the table when it is feeding to the left.

The center stop dog may be used to stop the table from feed in either direction, but it is supplied particularly to provide an automatic safety stop in the center of an automatic reciprocating cycle. It is mounted in the upper dog slot and acts to stop the table from both directions of feed.

Small socket head screws in the front face of the table prevent setting the dogs beyond their safe operating range. In addition, two fixed stop dogs are pinned to the front face of the table as a safety measure to prevent power movements of the table beyond its actual operating range.

Caution: Do not remove these stops from the front of the table in an effort to obtain greater travel, or you may seriously damage the machine.

To start an automatic cycle by means of the rear table control lever, the cycle must be such that you start in feed rather than rapid traverse. Cycles starting with rapid traverse cannot be started by means of the rear table control lever.

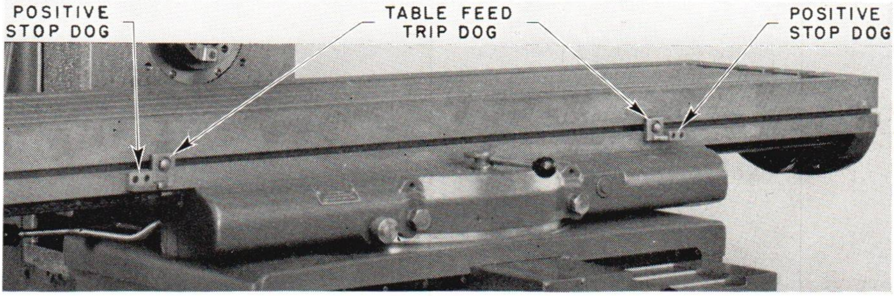


Figure 31
Table Trip Dogs for Universal Machines

Table Trip Dogs (Universal Machines). Two feed trip dogs are supplied with the Universal machine. They act only to trip the table out of feed to stop; there is no automatic reversal of direction or shift from rapid traverse to feed, or vice versa. In addition to the trip dogs, a separate pair of positive stop dogs are fastened to the front of the table to prevent moving the table beyond its actual operating range. Do not remove these fixed stop dogs in an effort to obtain greater travel or you may seriously damage the machine.

Saddle Trip Dogs. The power cross feed movement of the saddle can be stopped automatically at any desired point in its travel in either direction by means of trip dogs, adjustably mounted in a tee-slot beneath the left-hand side of the saddle (Figure 32). There are two dog trip plungers, one for each direction of travel of the saddle, and one dog is supplied for each direction of travel.

In addition to the trip dogs, a separate pair of positive stop buttons are built into the inside portion of the dog rail. These positive stop buttons engage a pair of positive stop plungers as a safety measure to prevent moving the saddle beyond its actual operating range.

Caution: Do not attempt to remove these positive stops in an effort to obtain greater cross travel or you may seriously damage the machine.

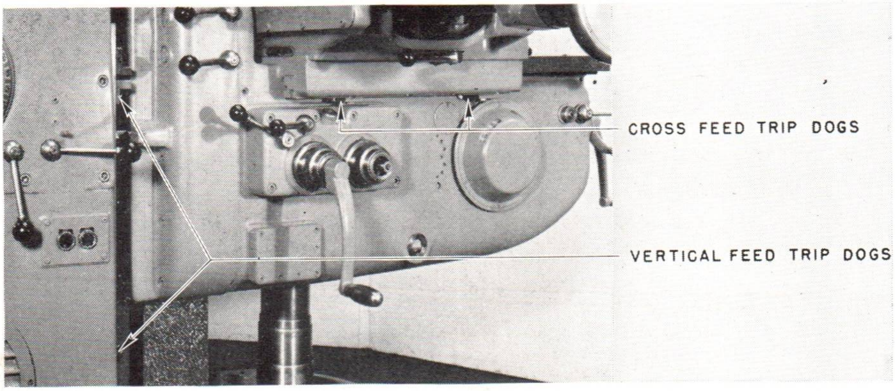


Figure 32
Knee and Saddle Trip Dogs

Knee Trip Dogs. The power vertical movements of the knee can be stopped automatically at any desired point in its travel in either direction by means of trip dogs, adjustably mounted in a tee-slot at the left-hand side of the column (Figure 32). Two dogs are supplied, one for each direction of travel. A fixed stop dog prevents setting the upper trip dog beyond its actual operating range and a fixed trip pin, set in the front of the column, limits the lower extreme of knee travel.

Caution: Do not attempt to remove the fixed stop dog or the fixed trip pin in an effort to obtain increased vertical movement or you may seriously damage the machine.

Overarm and Arbor Supports. The overarm may be positioned by first loosening the clamping lever and then turning the overarm adjusting crank (Figure 33). Turning the crank clockwise moves the overarm toward the front of the machine, while turning it counter-clockwise moves the overarm toward the rear. After the overarm is positioned, tighten the hand clamp. Horizontal machines are equipped with a Dynapoise unit which damps self-excited chatter.

The arbor supports may be positioned at any desired place on the overarm and clamped in position by tightening the clamping nuts (Figure 33).

Direction of Spindle Rotation. The spindle can be rotated in either direction to suit the "hand" of the cutter. Right-hand cutters require counter-clockwise rotation, left-hand cutters require clockwise rotation of the spindle. Direction of rotation is controlled by the spindle reverse lever

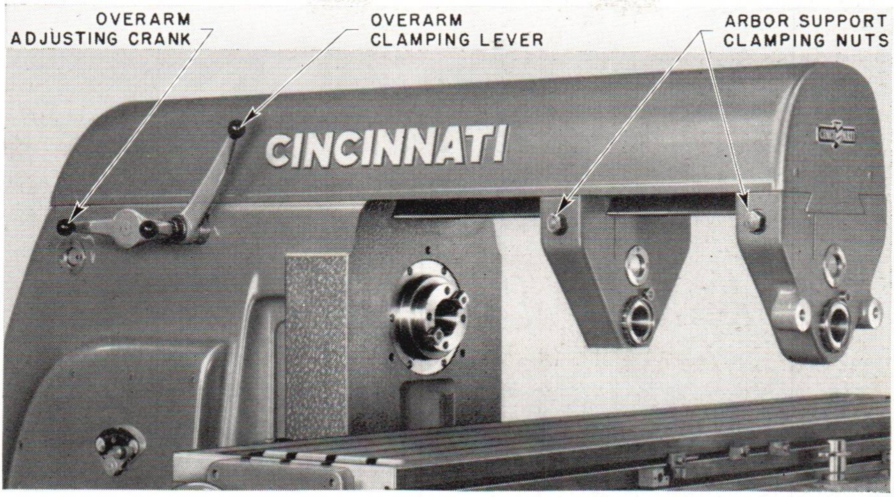


Figure 33
Overarm and Arbor Support Clamps

(Figure 20) and is indicated by the instruction plate adjacent to the lever. "RIGHT" indicated counter-clockwise rotation, "LEFT" indicates clockwise rotation.

General Setting Up Instructions. Clamp the fixture in the center of the table, or as near the center as operating conditions will permit, to avoid as much as possible the excessive overhang of the table which causes wear on the ends of the table gibs. If you are using a lathe dog for holding the work, do not under any conditions use the T-slots of the table for tightening the screw. When these T-slots become marred, the work or fixture which is located from them will not line up properly, with the result that a new table must be purchased or the old one replaned to obtain accurate work.

When using a cutter on an arbor the cutter must fit accurately and the arbor must run true between dead centers to obtain the best finish on the work and freedom from chatter. The cutter must be a snug fit on the arbor for the same reasons. The ends of the spacing collar and arbor nut must be perfectly clean before assembling, because dirt particles between the collars will spring the arbor when the nut is tightened. Always use as short an arbor as possible, and space the cutter as near to the spindle as operating conditions will permit.

When inserting the arbor in the spindle nose, make sure both the arbor and spindle nose are perfectly clean and free of any particles of lint. Any minute particles will throw the arbor out of alignment. The hole for the arbor draw-in bolt is located behind the rectangular cover at the rear of the machine.

When placing a face mill on the spindle, the best method is to place the mill on a block of wood resting on the table, and then raise the table until the face mill will slip over the spindle nose without undue physical exertion. Tighten each face mill screw a fraction of a turn until they are all tight.

Changing from Steel to Cast Iron Jobs. When milling a material which does not require a cutting fluid, such as cast iron, all strainers should be protected with the cover provided for them to keep fine chips and particles of metal out of the coolant system. Do not use compressed air for cleaning the machine when setting up for a new job. The chips may be blown into the bearings, resulting in untimely wear.

Safety Precautions. Safety stop dogs and stop buttons are provided for all sliding units. Do not remove these dogs in an effort to obtain more travel, as serious damage to the machine may result. If the job requires a greater range than the safety dogs allow, it must be milled on a machine with greater table travel.

The electrical compartment door should never be opened except by an experienced maintenance man for electrical control repair work.

The clutch on the table hand crank is provided with a spring to keep it out of engagement when it is not in use. Do not remove this spring for the sake of keeping the crank in engagement, as it may result in serious injury to yourself or some other operator.

Always stop the spindle before reversing the direction of rotation. Never try to reverse the spindle rotation while the spindle is running.

Do not try to change speeds while the spindle is running.

Do not try to change feeds unless all feed levers are in their neutral or stop positions.

Never let your hands rest on the table or table edge as you may get your finger caught between the trip dogs and trip plunger, resulting in serious injury.

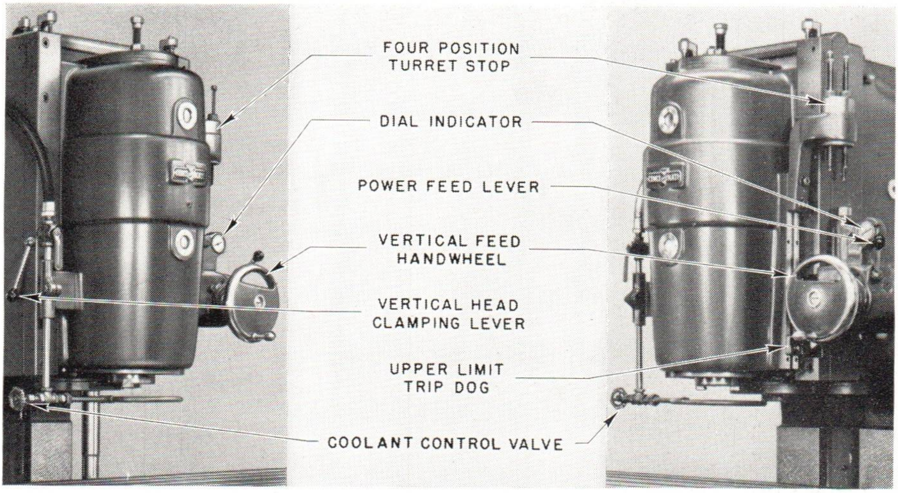


Figure 35
Vertical Head

OPERATING INSTRUCTIONS

Common to Vertical Machines only. Remainder of Operating Instructions are same as for Horizontal Machines.

Hand Feed to Vertical Head. The vertical head can be moved, by hand, when power feed is disengaged, by rotating the vertical feed handwheel (Figure 35). One clockwise turn of the handwheel moves the head down ⅛ inch. The micrometer dial is graduated into 125 spaces, which is equivalent to .001″ movement for each space. Be sure that you loosen the hand clamping lever (Figure 35) before trying to move the vertical head. To reset the micrometer dial, merely loosen the thumbscrew, rotate the dial to the desired setting, and then tighten the screw.

Power Feed to Vertical Head. Vertical power feed movements of the vertical head are engaged by means of the vertical head power feed lever (Figure 35). When the lever is moved up, the head moves up; when the lever is moved down, the head moves down. Be certain that you loosen the clamping lever before engaging the power feed. The power feed rates to the vertical head are ½ the feed rates shown on the feed dial.

Power Rapid Traverse to Vertical Head. The power rapid traverse to the vertical head is controlled by the vertical head power feed lever in conjunction with the power rapid traverse lever (Figure 26). To rapid traverse the head, first move the feed lever in the direction you want the head to move and then pull the rapid traverse lever upward. Rapid traverse rate to the vertical head is 75 inches per minute.

Clamping the Vertical Head in Position. The vertical head can be rigidly clamped to the column by means of the vertical head clamping lever (Figure 35) on the left-hand side and a clamping nut on the right-hand side of the head. Depending upon the size of the machine there may be either one or two clamping levers on the left-hand side and either a similar clamping lever or a clamping nut on the right-hand side. Be certain that you loosen these clamps before trying to move the head by hand or power.

Four-Position Turret Stop and Dial Indicator. The turret stop and dial indicator, shown in Figure 35, are standard equipment supplied with all Vertical High Power and Dual Power Dial Type Millers. The turret stop should be used as a *feed* trip only, downward power rapid traverse movement of the head should always be disengaged before the turret stop screw contacts the plunger at the top of the indicator bracket. Failure to do so may result in serious damage to the machine, if the head should "coast" after tripping the plunger. After tripping out of feed down, the vertical head should be lowered, by means of the vertical feed handwheel, to accurate final position as shown by the dial indicator. Upward power movements of the vertical head can be disengaged by the upper limit trip dog (Figure 35).

Rear Hand Adjustments. Rear hand adjustments of knee and saddle for the Vertical Machines can be supplied at extra cost. Operating instructions are the same as for the Horizontal Machines.

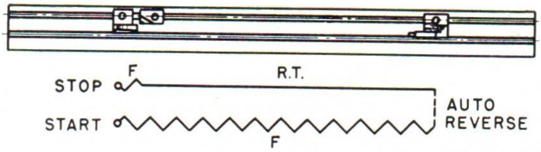
Rear Power Feed Controls. Rear power cross and vertical feed controls can be supplied at extra cost on the Vertical Machines. Operating instructions are the same as for the Horizontal Machines. A rear table feed control lever is supplied as standard equipment. With this lever the table feed can be operated from the rear working position. Rapid traverse is obtained by first engaging the feed lever and then the rapid traverse lever. See Figure 28A for functions of rear controls.

AUTOMATIC TABLE CYCLES

In reading the cycle drawings, they progress in the opposite direction to the actual table movement as this illustrates the relative movement between the trip plunger and the trip dogs so that the dog can be shown directly above the cycle function it controls.

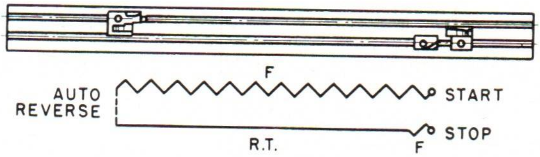
The short feed stroke at the end of some rapid traverse strokes is used to permit the table to be automatically stopped. If you have a cycle requiring more than one automatic stop, the second stop can be accomplished by using the center safety stop dog.

Cycles are started by shifting the table control lever to give the desired movement (see page 25).



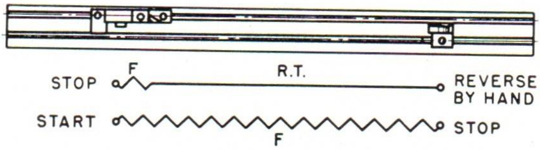
Cycle A

Simple milling cycle, automatic reverse and rapid return, feeding left. Feed left, automatic reverse, rapid traverse right, short feed right stop.



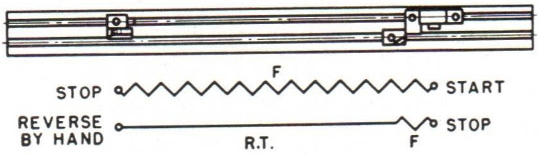
Cycle B

Same as "A", except feeding right. Feed right, automatic reverse, rapid traverse left, short feed left, stop.



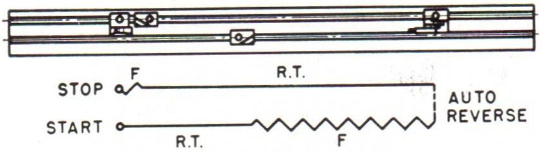
Cycle C

Simple milling cycle, feed to stop, hand controlled reverse and rapid return, feeding left. Feed left, automatic stop, reverse by hand, rapid traverse right, short feed right, stop.



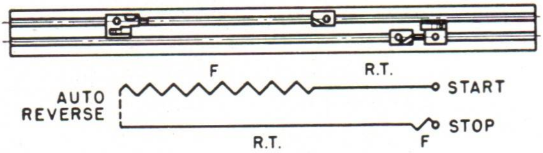
Cycle D

Same as "C", except feeding right. Feed right, automatic stop, reverse by hand, rapid traverse left, short feed left, stop.



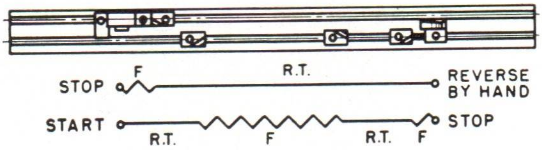
Cycle E

Simple milling cycle, rapid approach, automatic reverse and rapid return, feeding left. Rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, stop.



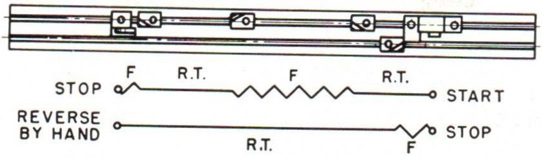
Cycle F

Same as "E" except feeding right. Rapid traverse right, feed right, automatic reverse, rapid traverse left, short feed left, stop.



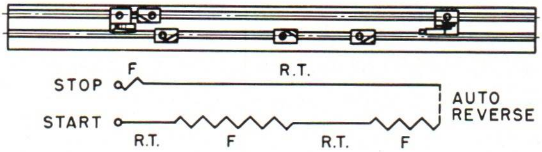
Cycle G

Simple milling cycle, rapid approach, rapid traverse to clear cutter, hand controlled reverse and rapid return, feeding left. Rapid traverse left, feed left, rapid traverse left, short feed left, stop, reverse by hand, rapid traverse right, short feed right, stop.



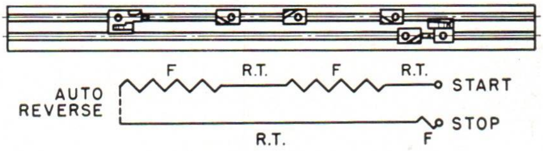
Cycle H

Same as "G" except feeding right. Rapid traverse right, feed right, rapid traverse right, short feed right, stop, reverse by hand, rapid traverse left, short feed left, stop.



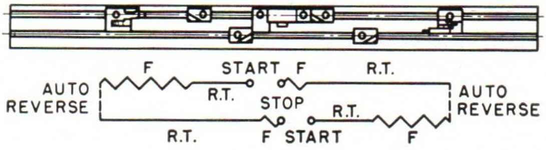
Cycle J

Intermittent feed cycle, rapid approach, automatic reverse and rapid return, feeding left. Rapid traverse left, feed left, rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, stop.



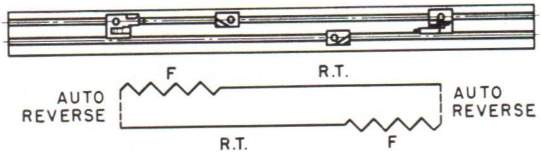
Cycle K

Same as "J" except feeding right. Rapid traverse right, feed right, rapid traverse right, feed right, automatic reverse, rapid traverse left short feed left, stop.



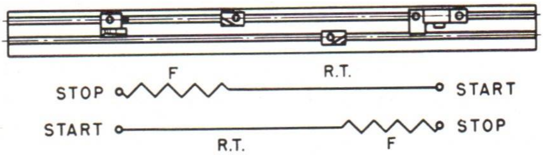
Cycle L

Reciprocating cycle, rapid approach, automatic reverse and rapid return, feeding both right and left, with center safety stop. Rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, stop. Rapid traverse right, feed right, automatic reverse, rapid traverse left, short feed left, stop.



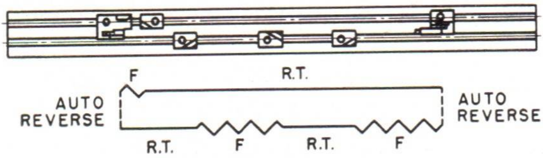
Cycle M

Continuous reciprocating cycle, rapid approach, automatic reverse, feeding both left and right. Rapid traverse left, feed left, automatic reverse, rapid traverse right, feed right, automatic reverse, and repeat the foregoing steps continuously.



Cycle N

Reciprocating cycle, rapid approach, stop at each end, feeding both left and right. Rapid traverse left, feed left, stop. Reverse by hand, rapid traverse right, feed right, stop.



Cycle O

Continuous, intermittent cycle, rapid approach, automatic reverse and rapid return, feeding left. Rapid traverse left, feed left, rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, automatic reverse and repeat foregoing steps continuously.

ADJUSTMENTS

Adjusting the Gibs. Both headless (Figure 42B) and head-type (Figure 42A) gibs are provided to compensate for wear of the bearing surfaces between the various sliding elements. Keep the bearing surfaces clean to avoid excessive wear caused by dirt and grit. When adjustment of the gibs is necessary, they should never be drawn up so tightly as to prohibit free movement of the particular unit by the hand adjustment. Tight adjustment squeezes out the oil film, resulting in rapid wear.

Knee Gibs. Five headless type gibs are used to compensate for wear between the knee and column on Nos. 4, 5 and 6 size machines. Two are located on the left side of the knee, one each at the top and bottom; two on the right side of the knee; and one at the center of the knee. Three gibs are used on No. 3 size machines, one on each side and one at the center. The latter is covered by a wiper which must be removed before adjustment can be made. Always position the knee centrally in its range of travel before attempting to adjust the gibs.

Table Gib. A head type gib is provided to compensate for wear between the table and saddle (table and housing on Universal Machines). It is located on the left-hand side of the saddle or housing.

Saddle Gibs. Three headless type gibs are used to compensate for wear between the saddle and knee; one on the left side of the saddle ways, one on the right side, and one on the right center of the top saddle way.

Vertical Head Gibs. Three head-type gibs are provided to compensate for wear between the vertical head and the column, two on the left-hand side, and one at the right at the top of the column.

Adjusting Head Type Gibs. To adjust for wear with any of the head type gibs, proceed as follows with the machine stopped and the clamps for that particular slide released (see Figure 42A):

1. Loosen the lock nut.
2. Rotate the adjusting screw in a clockwise direction for several turns.
3. Rotate the lock nut in a clockwise direction until the gib is tight, then back it away two or three turns.

4. Rotate the adjusting screw in a counterclockwise direction until the flange portion engages the head of the gib, then continue turning it in the same direction for approximately one full turn.

5. Lock the gib and screw in position by tightening the lock nut.

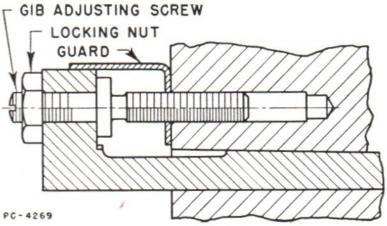


Figure 42A
Head Type Gib

This adjustment should cause a slight drag on the movement of the slide by means of the hand control.

Adjusting Headless Type Gibs. To adjust for wear with any of the headless gibs, proceed as follows with the machine stopped and the clamps for that particular slide released (see Figure 42B):

1. Turn the adjusting screw clockwise to force the gib snugly into place.

2. Rotate the adjusting screw counterclockwise about one full turn.

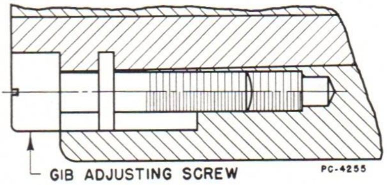


Figure 42B
Headless Type Gib

This adjustment should cause a slight drag on the movement of the slide by means of the hand control.

Adjusting the V-Belt Tension. If the V-belts slip due to stretch or wear, they can be tightened in the following manner:

1. Open the motor compartment door.

2. Loosen four motor mount clamping bolts (Figure 42C) and allow the motor to settle in position from its own weight.

3. Retighten the bolts and close the motor compartment door.

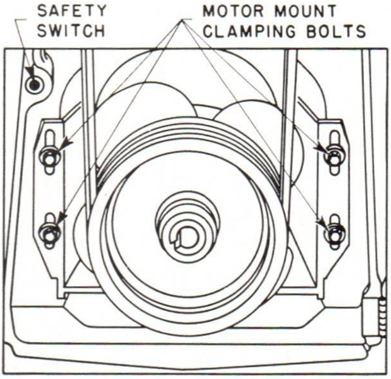


Figure 42C
Belt Tension Adjustment

A few words on the care of V-belts: Keep oil and grease away from them. Never apply belt dressing. Be sure pulleys are in line. When replacing worn belts use only complete sets of matched belts.

Adjusting the Main Drive Clutch. The main drive clutch will seldom require adjustment as it is self-compensating for a considerable amount of wear. Need for adjustment is indicated if the cutter fails to maintain speed under normal cut loads, or if spindle hesitates before coming up to full speed when the starting lever is engaged. Always check to see that the column oil pressure is correct (see page 47) and the V-belts correctly tensioned before attempting to adjust the clutch. If adjustment is needed proceed as follows (Figure 43):

1. Open the motor compartment door.

2. Pull back the spring-loaded latching pin which is carried near the periphery of the roller finger assembly and rotate the roller finger assembly slightly in a clockwise direction. Release the latching pin and continue clockwise rotation until the pin drops in the next latching hole.

3. Repeat the operations described in Item 2 (above), until the clutch cannot be fully engaged, with rollers up on the flat portion of the spool, when the clutch spool is pushed in by hand.

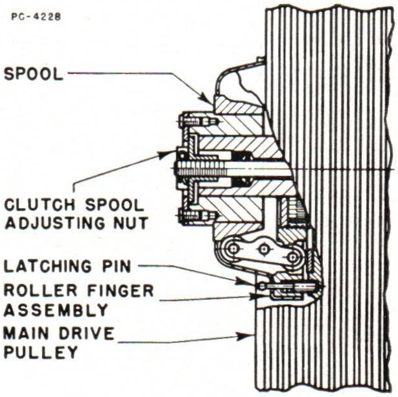


Figure 43
Main Drive Clutch Adjustment

4. Pull the latching pin back and rotate the roller finger assembly counterclockwise, one hole at a time, until the clutch can be fully engaged, with rollers up on flat portion of spool, when spool is pushed in by hand. Correct adjustment is attained when the clutch spool can be pushed into engagement with one hand.

5. Check the clearance between the clutch spool and the rollers with main drive clutch disengaged and speed selector lever engaged to rotate the speed dial. It will be necessary to depress the safety switch button by hand (see page 19) in order to start the machine. There should be approximately $\frac{1}{32}$ inch clearance between rollers and spool.

6. If clearance is incorrect it can be adjusted by removing the cotter pin through the clutch spool adjusting nut, rotating the nut until clearance is correct, and replacing the cotter pin.

Adjusting the Lead Screw Bearings. The table lead screw is equipped with two tapered roller bearings on the right-hand end. Backlash or "play" in the handwheel should be approximately .005″ as measured on the micrometer dial. If an excessive amount of play should develop, the bearings can be adjusted as follows:

1. Remove the bell shaped cover from the right-hand end of the table.
2. Loosen the table gib lock nut (see Figure 42A) and back off the gib (turn gib adjusting screw two or three turns counterclockwise).
3. Loosen the adjusting nut lock screw (Figure 44) and tap it lightly to free the locking shoe.
4. Turn the adjusting nut counterclockwise to be sure it is "free" then turn clockwise until tight and back off about 1/16 of a turn.

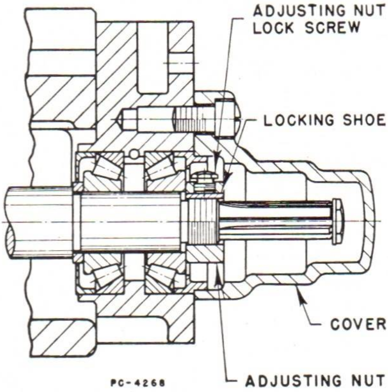


Figure 44
Table Lead Screw Bearing Adjustment

5. Tighten the lock screw and replace the cover.
6. Turn the table traverse handwheel, with the power feed disengaged, and try to determine by "feel" whether or not the bearings have been adjusted correctly. Any feeling or binding in the "play" movement of the handwheel indicates that adjustment is too tight.
7. Readjust the gib and tighten the lock nut.

When the "play" is caused by a worn lead screw and nut, it is necessary to replace these parts in order to obtain accurate work.

Adjusting the Cross Screw Bearings. The cross feed screw is supported in its front end in a pair of tapered roller bearings. Backlash or "play" in the handwheel should be approximately .005″ as measured on the micrometer dial.

If an excessive amount of "play" should develop, the bearings can be adjusted as follows (see Figure 45):

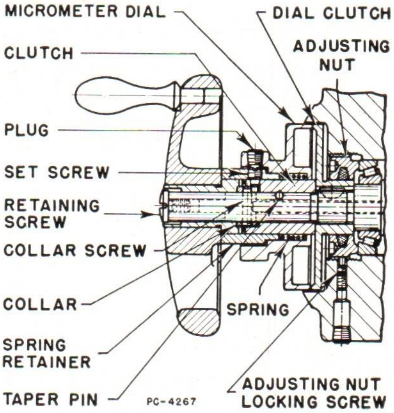


Figure 45
Cross Screw Bearing Adjustment

1. Loosen each of the saddle gib adjusting screws (see page 42) several turns.
2. Remove the retaining screw in the center of the cross feed handwheel and remove the handwheel.
3. Remove pipe plug from knurled portion of the micrometer dial.
4. Turn dial until a set screw is visible through the pipe plug hole. Remove this set screw.
5. Slip the dial, spring retainer, and spring off the clutch.
6. Knock out the taper pin through the clutch, remove the collar screw, and remove the clutch and collar.
7. Insert an eye bolt in each of the two threaded holes in the dial clutch and remove it by pulling straight out. Threaded holes are 3/8″—16.
8. Unscrew the pipe plug from the side of the knee, just beneath the power rapid traverse lever, and remove the two set screws beneath. The bottom screw is the adjusting nut locking screw.
9. With a face spanner wrench turn the adjusting nut until it is tight, then back it off about one slot on periphery of nut and align slot with adjusting nut locking screw.
10. Replace locking screw and all other parts in the reverse order from that in which they were removed.

Adjusting the Spindle Bearings. If the spindle bearings should run too hot, or if an excessive amount of "run out" or "end play" should develop, the bearings should be adjusted. Temperature can be measured by removing one of the cap screws from the spindle nose oil retainer cap, and inserting the thermometer in the screw hole. Temperature should not exceed 145° F. after four hours of running at high speed. "Runout" can be checked with a dial indicator by mounting an arbor and indicating to the arbor. "Runout" should not exceed .0008″ at a point 6″ from the spindle nose. If adjustment of the spindle bearings is necessary, proceed as follows:

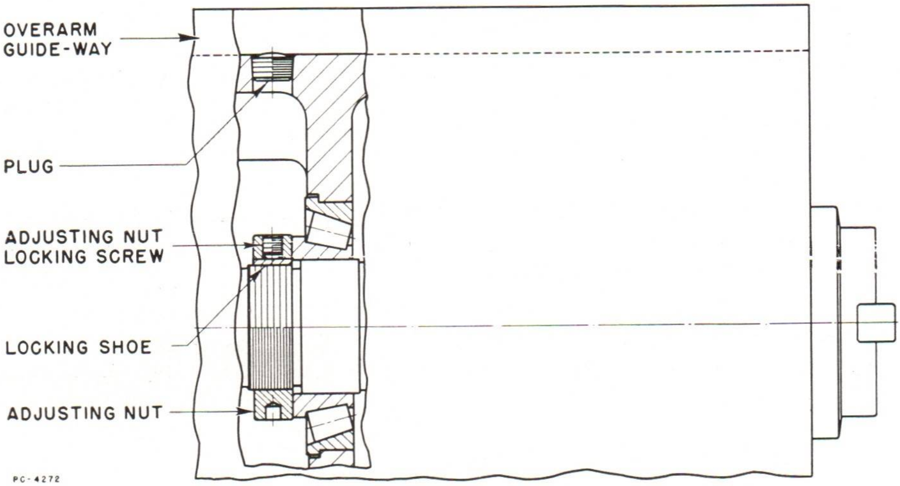


Figure 46
Spindle Bearing Adjustment

1. Start the machine and run the spindle at some speed in the high range above 500 rpm. Stop the spindle and set the spindle reverse lever (Figure 20) in the center or neutral position.
2. Remove the two driving keys from the spindle nose and clamp a 1″ square steel bar about 12″ long into the slots.
3. On horizontal machines remove the circular panel on the right-hand side of the column, or remove the overarm and the screw-plug in the center of the overarm guide-ways (see Figure 46).

   On vertical machines remove the pipe plug from the front of the vertical head, just below the name plate.
4. With a long Allen wrench, loosen the adjusting nut locking screw and tap the wrench to loosen the locking shoe beneath the screw.

5. Insert a steel bar into one of the radially drilled holes in the adjusting nut, and, by means of the bar clamped in the spindle nose, rotate the spindle counterclockwise about one revolution and then clockwise until the bearings are drawn up tight.
6. Remove the bar from the adjusting nut and rotate the spindle by means of the bar in the spindle nose to be sure that bearings are properly seated.
7. Check the "run out" and operating temperature as previously described to be sure that adjustment has been properly made.
8. Tighten the adjusting nut locking screw and replace the driving keys in the spindle nose. Replace the cover on the side of horizontal machines, or the pipe plug if it is a vertical machine.

Adjusting Column Hydraulic Oil Pressure. Too low an oil pressure in the column hydraulic system will manifest itself by sluggish or erratic action of the speed shifter mechanism, or faulty action of main drive clutch and brake. Too high a pressure is rather improbable, but would be indicated by excessive leaking of oil. It is best to check this pressure every couple of months and re-adjust if necessary. To check and adjust pressure proceed as follows:

1. Start machine and run until oil is warm, then stop the machine.
2. Remove the ¼" pipe plug from the left-hand side of the column, just under the speed dial. Insert a 500 psi pressure gage in this hole.
3. Start the machine. The operating pressure should be 265-280 pounds per square inch. If too low or too high, it can be corrected as follows.

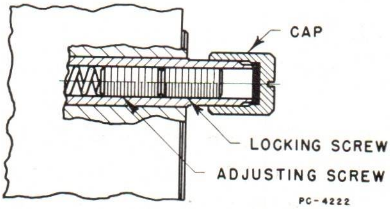


Figure 47
Column Oil Pressure Adjustment

4. Open the motor compartment door. The relief valve which controls the column oil pressure is located in rear of column to the left of the driven pulley (see Figure 50). Remove the slotted cap and the locking screw (Figure 47), and adjust by means of the adjusting screw.
5. Replace locking screw and cap. Stop machine, remove pressure gage and replace the pipe plug.

Adjusting the Knee Hydraulic Oil Pressure. Too low an oil pressure in the knee hydraulic system will manifest itself by sluggish action of the feed box when changing feed rates, or erratic action of machine movements when rapid traverse is engaged. Too high a pressure is rather improbable, but would be indicated by excessive oil leakage. It is best to check this pressure every couple of months and readjust if necessary. To check and adjust pressure, proceed as follows (see Figure 48):

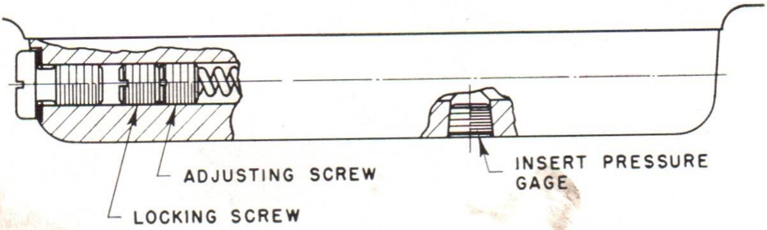


Figure 48
Knee Hydraulic Oil Pressure Adjustment

1. Start machine and run until oil is warm, then stop the machine.
2. Remove the 1/8″ pipe plug from the rectangular plate on the lower left side of the knee. Insert a 500 psi pressure gage in this hole.
3. The relief valve is located in a hole in the rear face of the rectangular plate. Remove the slotted screw and the locking screw.
4. Start the machine. The operating pressure should be 110 to 120 pounds per square inch when oil is warm. If low or high it can be corrected by means of the adjusting screw.
5. Replace the locking screw and the slotted screw. Stop machine, remove pressure gage and replace pipe plug.

Adjusting the Vertical Screw Brake. The knee elevating screw mechanism is provided with a multiple disc type brake. Adjustment of the brake would be indicated if the knee should "coast" more than ten divisions on the micrometer dial after lowering the knee at the rapid traverse rate. To adjust the brake proceed as follows (see Figure 49):

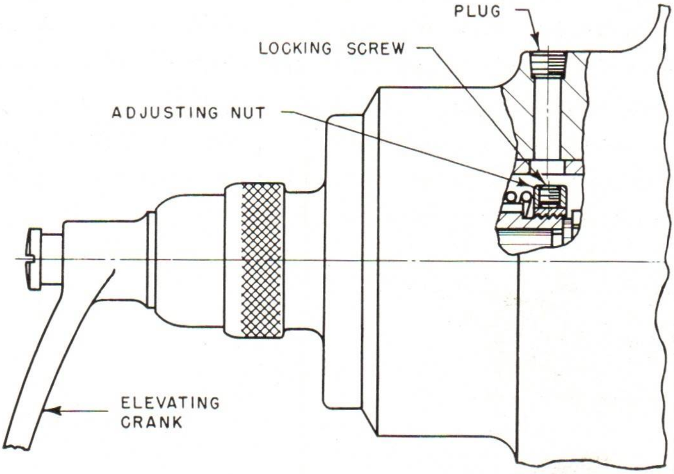


Figure 49
Vertical Screw Brake Adjustment

1. Two pipe plugs are located on the left-hand side of the boss from which the knee elevating crank projects. Remove the front plug.

2. Rotate the knee elevating crank until the locking screw in the adjusting nut is aligned with the hole.

3. Loosen the locking screw slightly and tap the wrench to loosen the locking shoe beneath the screw.

4. Leaving the wrench in the locking screw, turn the elevating crank counterclockwise a slight amount to be sure locking shoe is loose and then turn crank clockwise for approximately one full revolution. Retighten the locking screw and replace the pipe plug.

Note—When brake is correctly adjusted it should require approximately 180-inch-pounds of torque to keep the elevating crank moving in a counterclockwise direction to lower the knee. This can be checked by hooking a spring scale over the handle of the knee elevating crank and pulling the crank in a counterclockwise direction. The scale should register approximately 20 pounds if brake is correctly adjusted.

Cleaning the Column Oil Strainer. The pump intake line in the hydraulic oil reservoir in the column is provided with a strainer which should be periodically removed and cleaned. To clean the column strainer proceed as follows:

1. Drain the oil from the column reservoir. The drain is located just below the filler opening (Figure 16, station 15).

2. Open the motor compartment door. The strainer is screwed into the rear face of the column.

3. Unscrew the strainer head from the rear of the column. On some machines it may be necessary to remove the vee-belts before unscrewing the strainer.

4. Wash the strainer with solvent and blow clean with air.

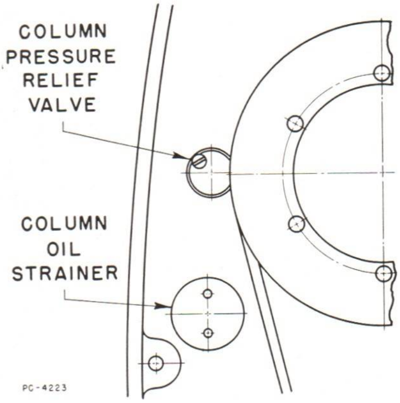


Figure 50
Column Oil Strainer

5. Replace the strainer. It is advisable to remove the large circular cover plate on the right-hand side of the column in order to be able to guide the strainer onto the suction line. Be sure the gasket is in place under the head of the strainer.

6. Replace cover on side of column and fill reservoir with clean oil.

Automatic Backlash Eliminator Adjustment. The mechanism is self-compensating for wear and so should not require adjustment unless dismantled or tampered with. Correctness of the adjustment can be easily checked and corrected as follows (see Figure 51).

1. Remove the slotted screw plug from the center of the backlash eliminator disengaging knob.

2. Repeatedly engage and disengage the table power movements in either direction. Observe or indicate to the disengaging sleeve locking screw or the sleeve itself. They should move out about $\frac{1}{64}''$ when table power feed movement is engaged. If adjustment is necessary it can be accomplished by proceeding as follows:

3. Remove the disengaging sleeve locking screw, the disengaging sleeve, and the disengaging knob.

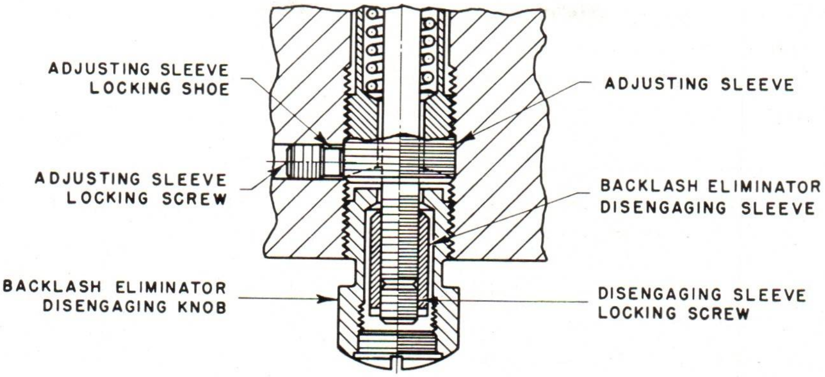

ADJUSTING SLEEVE LOCKING SHOE
ADJUSTING SLEEVE LOCKING SCREW
BACKLASH ELIMINATOR DISENGAGING KNOB
ADJUSTING SLEEVE
BACKLASH ELIMINATOR DISENGAGING SLEEVE
DISENGAGING SLEEVE LOCKING SCREW

Figure 51
Backlash Eliminator Adjustment

4. Loosen the adjusting sleeve locking screw slightly and tap the screw to loosen the locking shoe beneath. This screw is located behind the backlash eliminator disengaging knob, in the front face of the saddle, in plain and vertical machines. In universal machines this screw is behind the disengaging knob, but on the under side of the universal housing.

5. Push inward on the end of the threaded member which projects through the adjusting sleeve, and while holding it in, turn the adjusting sleeve in a clockwise direction until it seats tight against the shoulder of the rack and back it off about one-third of a turn.

6. Retighten the adjusting sleeve locking screw.

7. Replace the backlash eliminator disengaging knob. Screw it in until it touches the adjusting sleeve and then back it off two complete turns.

8. Replace the disengaging sleeve on the threaded end of the rack. Screw it in until it touches the inner shoulder of the disengaging knob and then back it off one complete turn.

9. Hold the disengaging sleeve so it cannot turn and replace the disengaging sleeve locking screw as tightly as possible.

10. Replace the screw plug in the disengaging knob.

RECOMMENDED CUTTING FLUID

CIMCOOL, a product of The Cincinnati Milling Machine Co., is a cutting fluid resulting from a mixture of CIMCOOL Concentrate and CIMCOOL Water Conditioner with water. CIMCOOL is recommended because of certain outstanding advantages, particularly in cleanliness and sterility and absence of vapors, hot chips and slippery film.

CIMCOOL Water Conditioner is mixed in the ratio of one part to 200 parts of water, regardless of the ratio of CIMCOOL Concentrate.

Before adding Concentrate to water, always add CIMCOOL Water Conditioner in correct quantities. This conditioner contains the anti-rust, wetting and germicidal agents necessary for satisfactory use of CIMCOOL Concentrate. Never mix CIMCOOL with other cutting fluids. Clean systems and tank thoroughly before using.

Note—Always add premixture of CIMCOOL Concentrate with Water Conditioner and water when replenishing cutting fluid supply.

The amount of CIMCOOL Concentrate varies with the nature of the job requirements. Following are listed the optimum concentrations of Concentrate to use when milling various materials.

Cast Iron. Ordinarily cast iron may be milled dry. If the cutter is small and the cut relatively deep, as when T-slotting or rounding out keyways, an air blast from the compressed air line will keep the cutter sufficiently cool and will also clear out the chips. If the part deforms from the heat of machining or is too hot to handle, use one part CIMCOOL Concentrate to forty parts of conditioned water.

Brass, Soft Bronze and Aluminum. Normally milled dry. If the part deforms from the heat of machining or is too hot to handle, use one part CIMCOOL Concentrate to forty parts of conditioned water.

Mild Steel, Malleable Iron, Wrought Iron and Bronze. Use one part of CIMCOOL Concentrate to forty parts of conditioned water.

Cast Steel, Tool Steel and Hard Bronze. Use one part CIMCOOL Concentrate to twenty-five parts of conditioned water.

CIMCOOL may also be used with carbide tipped cutters; however, a large quantity of fluid should be supplied to insure uniform cooling and to avoid cracking the tips.

CLEANING THE COOLANT RESERVOIR AND COOLANT STRAINERS

The coolant reservoir, located in the base of the machine, should be cleaned out occasionally to maintain the full capacity for coolant. After pumping out the coolant, remove the cleanout cover on the left side of the base. With the aid of a scraper, similar to the soot scraper used on the old-fashioned coal range, scrape out the sludge. After the sludge has been removed, replace the cover. It is a good idea to coat the adjoining surfaces of the cover and base with some sort of sealing compound to prevent leakage.

Before refilling the reservoir, clean the two coolant strainers in the front base (Figure 53). Lift out the strainers and clean by washing in naphtha and then blowing them off with an air hose. Replace the strainers.

The coolant reservoir should then be filled with clean coolant. Coolant reservoir capacities are as follows: 20 gallons for the Nos. 3 and 4 Machines, and 25 gallons for the Nos. 5 and 6 Machines.

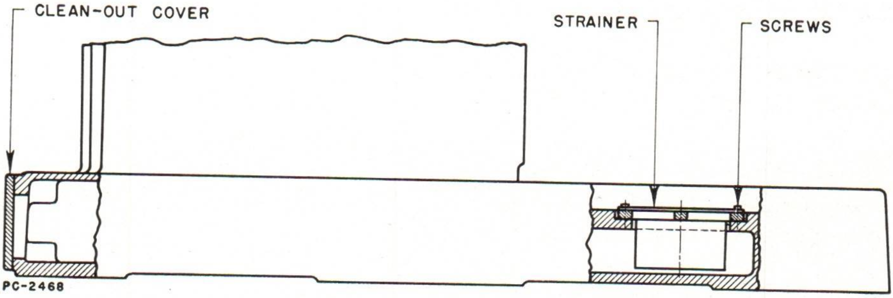


Figure 53
Cleanout Opening and Coolant Strainers

DIVIDING HEAD

Cincinnati Dividing and Spiral Milling Heads are used extensively in milling spiral and helical gears, constant velocity drum cams, etc. The manner of transmitting motion to the spindle in the head is the same for both types, but the construction of the main castings are entirely different. The Dividing Head is designed so that its spindle can be swiveled vertically, while the spindle of the Spiral Milling Head is rigidly fixed in a one-piece housing to provide an attachment suitable for heavy and continuous helical milling. The same type of Driving Mechanism is used for both types of heads; therefore the tables and instructions in this booklet apply to both.

The spindle of the dividing head is housed in a swivel block, allowing it to be swiveled to any angle from 5° below the horizontal to 50° beyond the vertical. This arrangement permits bevel gears of any pitch angle to be milled, and many other types of work requiring concentrically spaced slots or holes at an angle to the center line of the work piece.

The tailstock centers may be swiveled, and also raised or lowered, for taper work. The center-bar is reversible, to bring either the large or the small center point into working position.

Because of the splined shaft drive, the Dividing Head headstock need not be placed flush with the end of the table when set up with the driving mechanism. This is the type of set-up required for milling scrolls or certain types of cams.

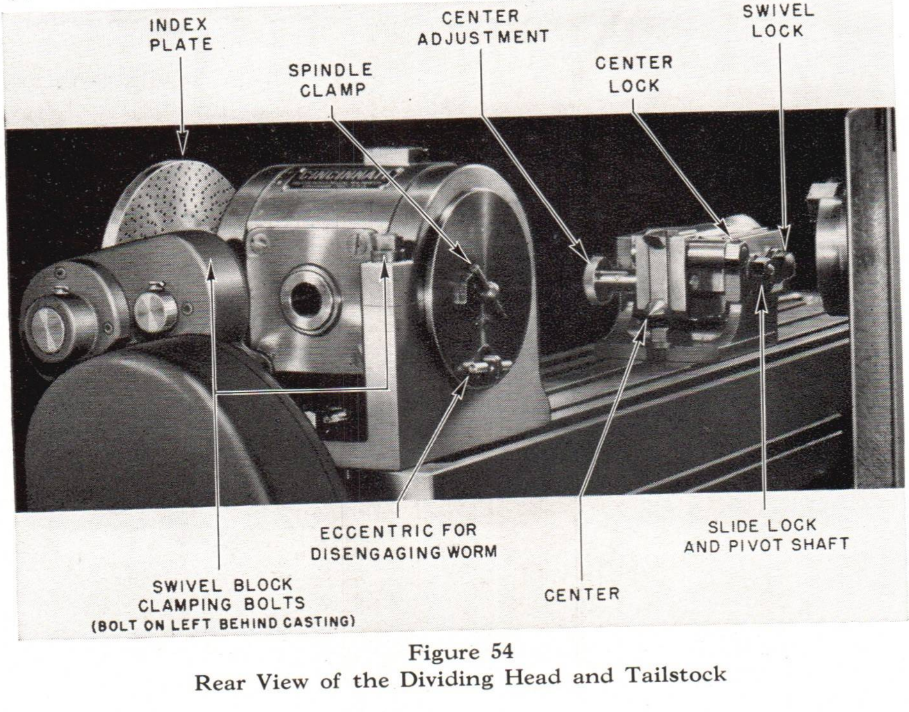

INDEX PLATE
CENTER ADJUSTMENT
SWIVEL LOCK
SPINDLE CLAMP
CENTER LOCK
ECCENTRIC FOR DISENGAGING WORM
SLIDE LOCK AND PIVOT SHAFT
SWIVEL BLOCK CLAMPING BOLTS (BOLT ON LEFT BEHIND CASTING)
CENTER

Figure 54
Rear View of the Dividing Head and Tailstock

LUBRICATION OF 10″, 12″, AND 14″ DIVIDING HEADS

The importance of proper lubrication cannot be over-emphasized. The continued accuracy and long life of the CINCINNATI Dividing Heads depend upon proper lubrication at all times, so do not neglect it.

Follow the instructions and specifications given below.

When to Oil	Station Number	Instructions	Parts Lubricated	Specifications
Daily (8 hours)	*2 and *3	Oil with a bench oiler	Mitre gears	P-31 Medium quality machine oil. Viscosity 190 to 210 seconds Saybolt at 100° F.
	*4		Mitre gear shaft	
	5		Spindle (rear)	
	6 and 7		Spindle (front)	
	8		Worm and bearing on yoke	
	9		Index shaft	
	10		Worm shaft on yoke neck	
	11		Index shaft and hub gear	
	12		Worm shaft in swivel bearings	
Weekly (when used)	**1		Gears in mechanism	

*Universal Dividing Head only.

**Wide Range Dividing Head only.

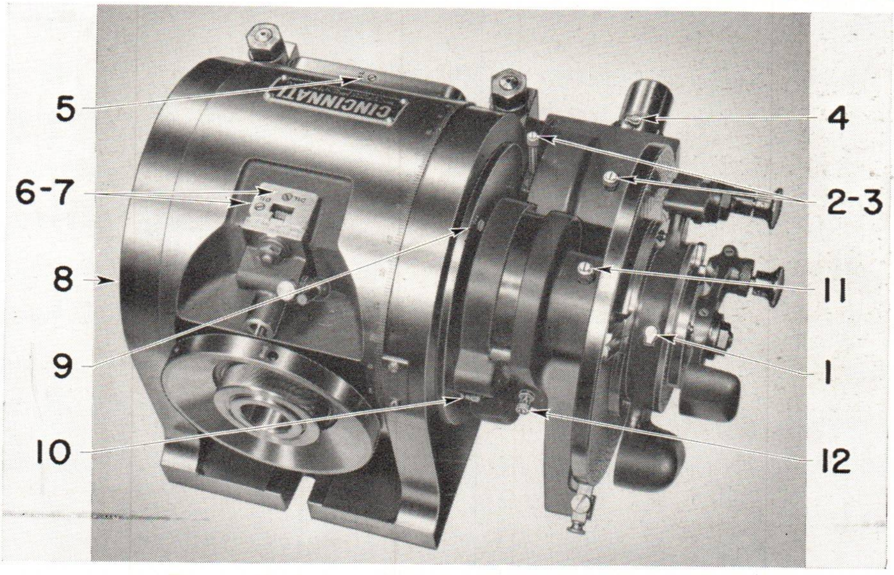


Figure 55—Lubrication Diagram—Dividing Head

SPECIFICATIONS FOR DIVIDING HEADS

	Size	Actual Swing	Taper Hole in. Spindle	Overall Length of Tailstock	Overall Length of Head	Distance from End of Spindle to Table when Spindle is Vertical	Approx. Weight	
							Dividing Head	Tailstock
Dividing Heads	10″	10½″	10 B&S	6 13/16″	13⅛″	10 7/16″	140 lbs.	39 lbs.
	12″	12½″	11 B&S	7⅛″	15⅛″	12¼″	225 lbs.	52 lbs.
	14″	14½″	11 B&S	7⅛″	15⅛″	13¼″	233 lbs.	55 lbs.
Ratio	40 to 1							
Holes Drilled in Side Index Plate	One side—24, 25, 28, 30, 34, 37, 38, 39, 41, 42, 43 Other side—46, 47, 49, 51, 53, 54, 57, 58, 59, 62, 66							
Holes Drilled in Front Index Plate	24, 30, 36							

The Sector. Index plates on all CINCINNATI Dividing Heads, Spiral Milling Heads and similar equipment have a sector for convenience in indexing. Figure 56 shows the sector set for 220 divisions, which requires that, for each division, the index pin move over a series of twelve holes (spaces) in the 66-hole circle. The hole in which the index pointer rests, should not be counted when setting the sector. This factor is sometimes the source of a mistake in setting up dividing head work, and must not be overlooked.

After the sector is spaced for the desired number of holes and tightened with the lock screw, no further counting of holes is necessary. Merely withdraw the index pin from the hole next to the left hand arm of the sector, relocate it in the hole next to the right hand arm, and then swivel the sector to again bring the left hand arm against the pin. The Dividing Head spindle and work will then have rotated 1/220 revolution (for the set-up illustrated).

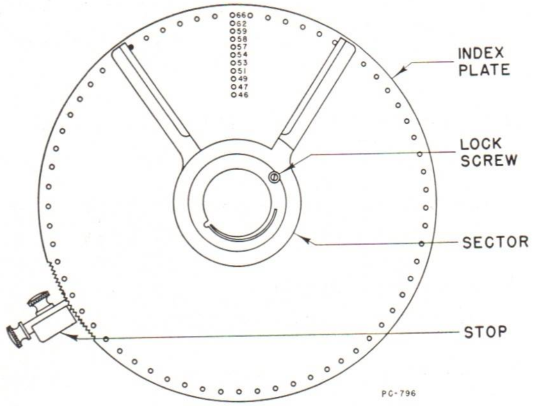


Figure 56
Dividing Head Sector Set for 220 Divisions

Example: Suppose you want the proper setting for a 21-tooth gear. Consulting the "Index Tables" you will find that for 21 divisions you must use the 42 hole circle. Set the index plate so that the side which has the 42 hole circle faces the index pin. Set the pin in any hole in that circle and space the sector for 38 spaces. Then for each of the 21 divisions, rotate the index pin through one revolution of the crank, plus the spacing of the sector, or 38 spaces.

Index Plate Stop. The index plate stop, Figure 56, engages notches in the index plate, preventing it from rotating. If the Head is connected to the driving mechanism for a spiral or helical milling job, the index plate, sector, and crank rotate as a unit. For such a set-up, *the stop must be disengaged from the plate.* In other words, the stop should be engaged only when the Dividing Head is not connected to the power drive, as when milling spur gears, bolt heads, etc. The stop serves as a safety precaution in preventing mistakes which would occur if the index plate itself were moved slightly while indexing.

The index plate stop may also be used as a guide to accurately reset work which has been removed from the Dividing Head for purposes of inspection. First reset the work in approximate relation with the cutter. Then withdraw the index plate stop, and with the index pin engaged, rotate the crank a sufficient amount to accurately position the work. Re-engage the stop in the notches on the rim of the plate. Two inches of the circumference of the plate is notched, and the notches have a pitch of .060″. Therefore, a movement of one notch on the index plate is equivalent to $\frac{1}{18460}$ of a revolution of the work.

Setting Up the Dividing Head and Driving Mechanism. The instructions outlined for this set-up should be followed in the order in which they are listed.

1. Clean the table of the milling machine and the bottom of the dividing head and tailstock.
2. Clamp the dividing head headstock in the center slot of the table, in a location suitable for the work.
3. Test the dividing head spindle with a test bar and indicator to see that it is parallel with the table.
4. Clamp the tailstock in the proper position, depending upon the length of the work.
5. Line up the tailstock center with the headstock center.
6. Line up the cutter central with the dividing head or tailstock center.
7. Lock the saddle in position.
8. Swing the table to the helix angle to be milled. (Universal machine only.) If a spiral milling attachment is being used on a plain machine, swing it to the helix angle to be milled.

9. Lock the housing in position. (Universal machine only.)
10. Withdraw the index plate stop (Figure 56). The index plate must be free to revolve with the index pin. *Note*—The stop engaging the notches in the rim of the index plate should be engaged only when the Dividing Head is used without the driving mechanism.
11. Set up the change gears.
12. Set the index plate sector for the proper spacing.
13. Oil the dividing head and change gears thoroughly.

Note—With the Driving Mechanism connected to the Dividing Head, especially when the head is equipped with a Wide Range Divider (page 66) we do not recommend the use of the power rapid traverse to the table.

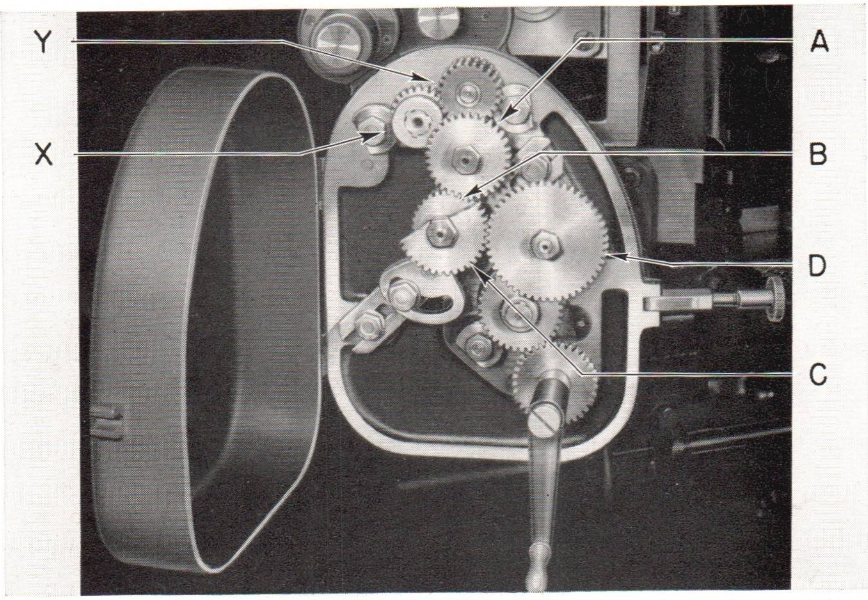


Figure 58
Standard Dividing Head Driving Mechanism

How to Select the Proper Change Gears. Suppose you want to cut a helix of 15¼″ lead. Consult the "Table of Leads" and find the lead which is nearest 15¼″—in this case 15.256″. The change gears for this lead, 51, 18, 21, and 39, may be used, because the lead obtained is close enough to the lead desired for practical purposes.

You will notice that gear "C" is not listed for some leads. In such cases only one intermediate gear "B" is required, and a collar replaces gear "C".

Setting Up the Change Gears. Remove the bell-shaped cover on the apron at the right-hand end of the table. It is held in position with a large slotted head screw. Then place the change gear segment on the apron, screw half-nuts on the two studs, and tighten them securely. Place the change gears in the positions indicated for the desired lead, being careful not to get gears "B" and "C" interchanged. The "hand" of the lead is fixed by gears "X" and "Y", as shown in the table below.

After the set-up has been completed, move the table by means of the hand feed crank, to be sure that the entire mechanism operates freely, before engaging the power feed. Remove the hand crank and keep the cover closed while the machine is in operation.

	Right-Hand Helix	**Left-Hand Helix**
Dividing Head	Remove gear Y Reverse gear X	Gears X and Y, as shown in Figure 58
12″ Spiral Head	Gears X and Y, as shown in Figure 58	Remove gear Y Reverse gear X

Leads Lower than Those Listed in Tables. With the standard driving mechanism illustrated in Figure 58, leads lower than those listed in the tables, pages 110 to 126, can be obtained, *using hand feed only* (rotating the index crank at the side of the head). To change the gearing for low leads, remove gear "D". A 34 tooth gear is now exposed, meshing with the 34 tooth gear on the lead screw (directly below gear "D"). Remove these two 34 tooth gears, and replace them with the standard 51 tooth change gear on the lead screw and the standard 17 tooth change gear on the stud for gear "D". Instead of a 1 to 1 ratio, we now have a speed-up of 3 to 1. Leads for the change gear combinations listed are now divided by 3. However, some of the change gear combinations are not obtainable because of interference with the segment.

This set-up should be used only for occasional jobs. If leads shorter than 2½″ are cut often, we recommend the short lead bracket. With this additional equipment, the range of leads is increased to ⅛″ to 100″. It should be installed at our factory. Complete instructions for this type of equipment is contained in a separate booklet "Table of Leads—⅛″ to 100″ Lead Driving Mechanism".

Leads Near the Low Range. When cutting leads within the low range of the Dividing Head driving mechanism, certain precautions must be observed. If, for example, the gears are set up for a 10″ lead, the ratio of the change gears is 1 to 1, and the table feed (lead) screw rotates 40 revolutions to one revolution of the dividing head spindle.

For leads greater than 10″, the dividing head spindle runs slower in relation to the speed of the lead screw. Example: 20″ lead, table feed screw rotates 80 revolutions, while the dividing head spindle rotates one revolution. This requires a change gear set-up which reduces the speed from the lead screw to the dividing head, resulting in a mechanical advantage in transmitting power

For leads shorter than 10″, the dividing head spindle runs faster in relation to the speed of the lead screw. Example: 5″ lead, table feed screw rotates 20 revolutions, while the dividing head spindle rotates one revolution. The change gear set-up for these low leads increases the speed from the lead screw to the dividing head, resulting in a mechanical disadvantage in transmitting power. The slow speed of the lead screw causes a "wind-up", which may produce a slightly jerky motion when milling short leads on large diameters of work. Therefore, conditions should be as nearly correct as possible when cutting short leads, particularly those from 2½″ to 5″. These conditions may be summarized in a few words. (*a*) the table gib should be correctly adjusted (not too tight), (*b*) the change gears should have a slight amount of back-lash, (*c*) the table ways and lead screw should be well oiled, (*d*) the table feed screw should rotate freely. Also, it might be noted that with a relatively high table feed, say 5¾″ per minute, a greater proportion of power is available at the dividing head.

When all contributing factors are correct, the machine will pull a reasonable cut with a set-up for the lowest lead of 2½″. If the cut should be unnecsarily heavy, then it is advisable to feed by hand. This may be done by allowing the table feed engaging lever to remain in neutral position and driving the dividing head and table by hand through the index crank in front of the index plate. With a short lead set-up hand feed is very easy, as the mechanical advantage is then in favor of the operator.

If leads lower than 5″ must be cut often, we recommend our short lead mechanism. (It may be applied to Universal machines only.) Then leads as low as ¼″ may be cut by power.

Rapid Traverse and High Feed Rates. When the driving mechanism is set up for low leads, *do not* engage the table rapid traverse, or use high feed rates. Rapid rates of table traverse drive the dividing head too fast, resulting in rapid wear or perhaps "freezing" of the dividing head spindle in the block, as they are fitted very closely to obtain accuracy in spacing.

Calculating the Change Gears Required for a Given Lead. Many leads can be obtained other than those listed in the table. They were omitted because the difference was too small for ordinary requirements, but if you do not find a lead in the table which is close enough to meet your needs, the following formula will enable you to calculate all the possibilities:

$$\frac{\text{Lead}}{10} = \frac{\text{Driven}}{\text{Drivers}} = \frac{A \times C}{B \times D}$$

Suppose you want a lead of 35.789″,

$$\frac{35.789}{10} = 3.5789, \qquad \frac{51 \times 36}{27 \times 19} = 3.579$$

Gear A = 51 Teeth
Gear B = 27 Teeth
Gear C = 36 Teeth
Gear D = 19 Teeth

Standard change gears furnished with enclosed driving mechanism:

1 — 17 teeth
1 — 18 teeth
1 — 19 teeth
1 — 20 teeth
1 — 21 teeth
1 — 22 teeth
2 — 24 teeth
1 — 27 teeth
1 — 30 teeth
1 — 33 teeth
1 — 36 teeth
1 — 39 teeth
1 — 42 teeth
1 — 45 teeth
1 — 48 teeth
1 — 51 teeth
1 — 55 teeth
1 — 60 teeth

A few gear combinations can not be used because of interferences (and consequently are not tabulated.) For example, lead 36.090, gears 48-19-30-21.

How to Calculate the Angle for Setting the Milling Machine Table or Spiral Milling Attachment. Suppose you want to mill a lead of 7½″ on a 3″ diameter *work piece. The angle for swiveling the table is not shown for this combination, but it can be calculated very easily from the following formula:

$$\text{Tangent of angle} = \frac{3.1416 \times \text{diameter}}{\text{lead}}$$

$$\text{In the above example, Tan. angle} = \frac{3.1416 \times 3}{7.5} = 1.2566$$

$$\text{Angle} = 51\tfrac{1}{2}^{\circ} \quad \text{(See table, page 130.)}$$

***Note**—Use pitch diameter in calculating helix angle for helical and spiral gears, worms, etc.

How to Calculate Indexing with the Side Plate. (Standard Dividing Head). In case a particular circle of holes on the index plate becomes worn through constant use, you may be able to use some other circle of holes and get the same result.

The following set of rules and example illustrate the procedure to follow in obtaining the maximum number of settings for any condition of indexing. Since the ratio between the worm and worm-wheel in the Cincinnati Dividing Head is 40 to 1, then:

1. Divide 40 by the number of divisions required. The result gives the number of turns or fraction of a turn of the index crank.
2. If a fraction of a turn is required, the denominator (the lower part of the fraction) represents the circle to use, while the numerator represents the number of spaces in the circle over which the index pin must pass.
3. Reduce the fraction to its lowest terms, and multiply both parts of the fraction by the same number until the denominator equals the number of holes in any circle.

Example

Suppose you want to calculate all the indexing circles for 3 divisions

$\frac{40}{3} = 13\frac{1}{3}$ turns of the index crank

One-third of a turn could be obtained by rotating the index pin over one space in a 3 division circle—(Rule 2). Since we do not have a 3 hole circle, we must use one into which the number of holes can be evenly divided by 3. For instance, 8 spaces in the 24 hole circle (8/24 = 1/3), 10 spaces in the 30 hole circle (10/30 = 1/3), etc. One-third of a turn can be obtained in any of the following circles:

$\frac{1 \times 8}{3 \times 8} = \frac{8}{24}$ or 8 spaces in the 24 hole circle
$\frac{1 \times 10}{3 \times 10} = \frac{10}{30}$ “ 10 “ “ “ 30 “ “
$\frac{1 \times 13}{3 \times 13} = \frac{13}{39}$ “ 13 “ “ “ 39 “ “
$\frac{1 \times 14}{3 \times 14} = \frac{14}{42}$ “ 14 “ “ “ 42 “ “
$\frac{1 \times 17}{3 \times 17} = \frac{17}{51}$ “ 17 “ “ “ 51 “ “
$\frac{1 \times 18}{3 \times 18} = \frac{18}{54}$ “ 18 “ “ “ 54 “
$\frac{1 \times 19}{3 \times 19} = \frac{19}{57}$ “ 19 “ “ “ 57 “ “
$\frac{1 \times 22}{3 \times 22} = \frac{22}{66}$ “ 22 “ “ “ 66 “ “

Example

Suppose you want to calculate all the indexing circles for 56 divisions.

$\frac{40}{56} = \frac{5}{7}$ of a turn of the index crank.

$\frac{5 \times 4}{7 \times 4} = \frac{20}{28}$ or 20 spaces in the 28 hole circle.

$\frac{5 \times 6}{7 \times 6} = \frac{30}{42}$ " 30 " " " 42 " "

$\frac{5 \times 7}{7 \times 7} = \frac{35}{49}$ " 35 " " " 49 " "

Angular Indexing. Tables for angular indexing with the standard and high number index plates are not tabulated in this book because they are little used as compared to numerical divisions. However, angular spacing can readily be calculated, keeping in mind that one complete turn of the index crank = 9°, one space in the 30 hole circle = 18′, and one space in the 54 hole circle = 10′. The tabulation at the right shows the angular movement of the Dividing Head spindle for a movement of the index crank of one space in the various hole circles.

Circle	One Space	Circle	One Space
24	22′ 30″	46	11′ 44″
25	21′ 36″	47	11′ 29″
28	19′ 17″	49	11′ 1″
30	18′ 0″	51	10′ 35″
34	15′ 53″	53	10′ 11″
37	14′ 36″	54	10′ 0″
38	14′ 13″	57	9′ 28″
39	13′ 51″	58	9′ 19″
41	13′ 10″	59	9′ 9″
42	12′ 51″	62	8′ 43″
43	12′ 33″	66	8′ 11″

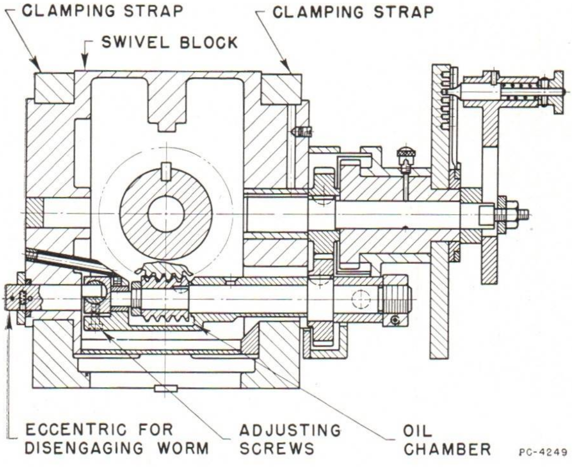


Figure 63
Section Through Dividing Head
Showing Worm

Plain Indexing with the Front Plate. Direct indexing is often used for making the divisions listed in the table on page 64 because it is faster than indexing with the side plate through the 40 to 1 worm reduction. To change the dividing head into plain index centers, turn the eccentric for disengaging the worm (Figure 63) through half a turn. The worm is then disengaged and indexing is accomplished by turning the spindle by hand.

The front plate (Figure 64A) is drilled with three circles of holes; 24, 30, and 36. It will index any number which divides evenly into any one of these numbers of holes in a circle. When changing from plain indexing back to universal indexing through the side plate, it is important that the front index pin be locked in its "out" position.

Indexing with the Front Plate

Divisions	Circles	Spaces	Divisions	Circles	Spaces
2	24 30 36	12 15 18	8	24	3
			9	36	4
3	24 30 36	8 10 12	10	30	3
			12	24 36	2 3
4	24 36	6 9	15	30	2
			18	36	2
5	30	6	24	24	1
6	24 30 36	4 5 6	30	30	1
			36	36	1

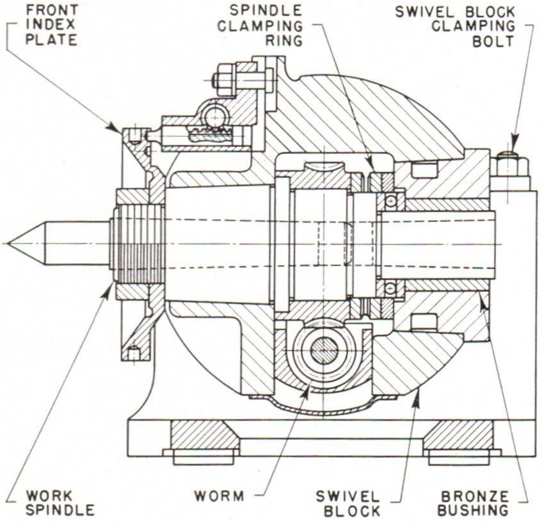


Figure 64A
Section Through Dividing Head
Showing Front Plate

Clamping the Dividing Head Spindle in Place. The spindle should be clamped in place (except when milling spirals) during heavy cutting operations to relieve all strains on the worm, worm-wheel, and index pin. (Figure 64B). Screw "A" forces wedge "B" into split ring "C", firmly clamping the spindle in place. Be sure to unclamp the spindle before turning the index crank or engaging the table feed while the head is set up for milling spirals.

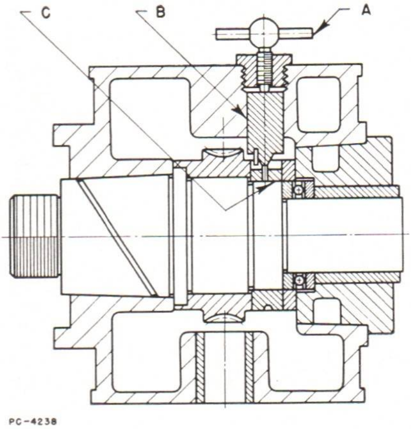


Figure 64B
Section Through Dividing Head
Showing Spindle Clamp

Adjusting the Dividing Head Worm. Wear between the worm and worm-wheel may be eliminated in the following manner:

1. See that the worm is engaged with the worm-wheel (Figure 63).
2. Remove the back-lash from the worm by tightening the locknut on the end of the worm shaft (Figure 63).
3. Remove the cover from the bottom of the swivel block (Figure 65).
4. Release fillister head screws "A-A", turn both set screws "B-B" the same amount in a counter-clockwise direction, and then retighten screws "A-A".
5. Turn the dividing head spindle by hand to see that it rotates freely with no evidence of back lash, and then replace the cover.

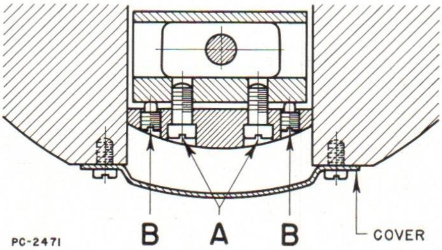


Figure 65
Section Through Worm Adjustment

THE WIDE RANGE DIVIDER

The Wide Range Divider applied to a Cincinnati Universal Dividing Head enables you to obtain divisions from 2 up to 400,000. It consists of large index plate "A", sector and crank "B", together with a small index plate "C", and sector and crank "D". The mechanism is so arranged that crank "D" operates through reduction gearing of 100 to 1 ratio enclosed in housing "G". The ratio between the worm shaft and the spindle is 40 to 1.

Set up for indexing in the conventional manner. The divisions given in the table (page 105) can be obtained by utilizing crank "B" only in combination with the proper hole circle on the large plate. (Large plate drilled on both sides and contains 11 circles of holes on each side). The index pin in crank "B" can be swiveled to any hole circle. When indexing in this conventional manner, the operation is exactly the same as it is on the regular Cincinnati Dividing Heads.

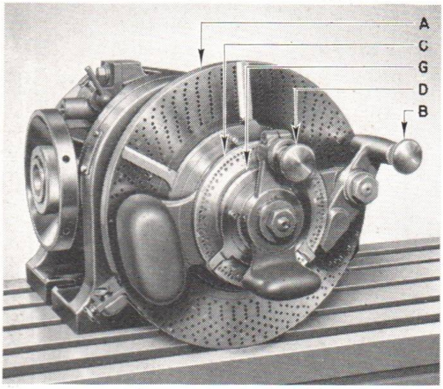


Figure 66
Wide Range Divider

How to use the Wide Range Divider. Any whole number of divisions, up to and including 60, and hundreds of others, can be obtained with the large plate only, and the setting may be read directly from the table, page 105. If the number of divisions required is not listed in the table, calculate the setting in the following manner:

Set-up

*1. Divide 400,000 by the number of divisions desired, for example 67. The result gives you a whole number quotient and a fraction—$5970\frac{10}{67}$.

2. Set the sector on large index plate "A" for 59 spaces on the 100-hole circle, 59 being the first two whole numbers of the quotient obtained.

3. Set the sector on the small index plate "C" for 70 spaces on the 100-hole circle, 70 being the last two whole numbers of the quotient obtained.

*__Note__—Should the quotient be a five-digit number, the first number represents the number of full turns of crank "B". (No five-digit quotient appears when making divisions higher than 40, and furthermore, calculations are unnecessary for any number less than 61.)

Operation

4. Index crank "B" an amount equal to the sector setting, namely—59 spaces.

5. Then index crank "D" an amount equal to the sector setting, namely—70 spaces. (Both cranks are moved in the same direction.)

6. Compensate for fraction 10/67 by adding one space to the index movement of the small crank "D" at intervals equal to the nearest whole number obtained by dividing 1 by 10/67. The result of this division is 7. Therefore, every seventh division, index 71 spaces on the small plate "C" instead of 70. In this way one space is lost, but the resulting error is equal to only .0000942″ on a 12″ diameter circle.

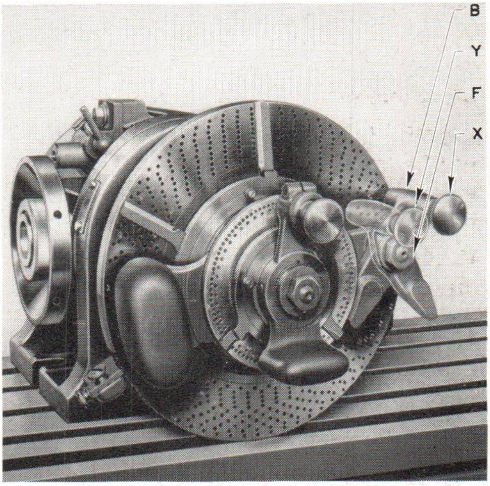


Figure 67

When indexing in the conventional manner (divisions tabulated on page 105), index crank "B" may be changed to a different circle of holes, as from "X" to "Y", by merely loosening nut "F"

Angular Spaced Divisions. If the divisions are spaced in degrees, minutes, and seconds, the procedure in calculating the setting is very similar to that outlined above, except that for sake of convenience, use the 54-hole circle on both plates. Complete tables are listed on pages 108 and 109.

Using crank B on the large plate (Figure 66A):

(*a*) One complete turn is equivalent to 9 degrees.
(*b*) Six spaces in the 54-hole circle equals 1 degree.
(*c*) One space in the 54-hole circle equals 10 minutes.

Using crank D on the small plate:

(*a*) One complete turn of crank "D" equals 5 minutes and 24 seconds.
(*b*) Ten spaces in 54-hole circle equals 1 minute.
(*c*) One space in 54-hole circle equals 6 seconds.

Example. Indexing an Angle of 3 Degrees, 20 Minutes, 12 Seconds.

Set-up

1. Consulting the "Degree" table on page 108, set the sector on index plate "A" (Figure 66) for 18 spaces on the 54-hole circle.
2. Consulting the "Fractions of a Degree" table on page 109, set sector "G" on plate "C" for 40 spaces on the 54-hole circle.

Operation

1. Index large crank "B" (Figure 66) an amount equal to the sector setting, namely—18 spaces.
2. Index small crank "D" three turns (see table) plus the sector setting, namely—40 spaces. (Both cranks are moved in the same direction.)

The index pin in the crank for the small plate is eccentric to provide a method of adjusting the pin from the 100-hole to the 54-hole circle, and vice versa. Merely loosen screw "E" (Figure 68), rotate the pin to the desired circle of holes, and then retighten the screw.

Reversing the Large Index Plate (Wide Range Divider). If the set-up requires the reversal of the large index plate, the operation may be accomplished in the following manner:

1. Remove nut "A" and the washer behind it. (Figure 68).
2. Slip differential unit "B" off the shaft.
3. Sector "C" is now free and may be removed.
4. Remove four screws "D", reverse the plate, and reassemble the parts.

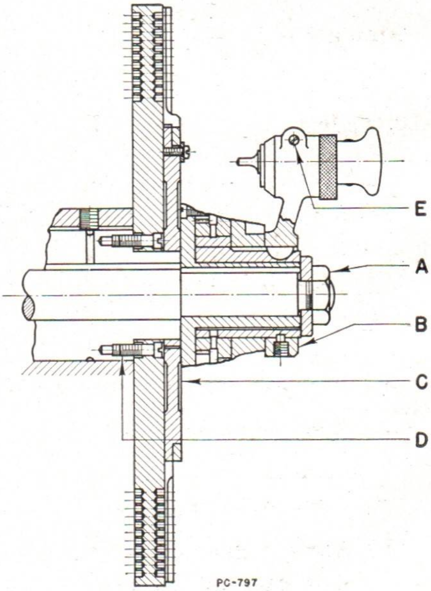


Figure 68
Section Through Differential Mechanism

MILLING CAMS

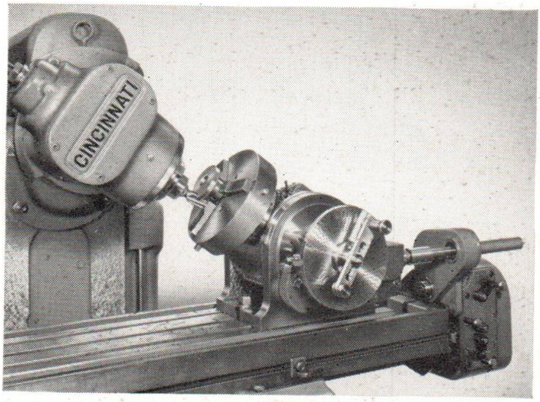


Figure 69
Diagrammatic Sketch of Dividing Head Set Up For Milling Cams

Rise and fall cams having a relatively narrow face may be machined by using the type of set-up indicated in Figure 69. The cutter may be supported in any type of swiveling head, such as a Universal Spiral Milling Attachment, Motor Driven Universal Milling Overarm Attachment, or Heavy Vertical Attachment. Almost any cam lead can be machined, and by trying different machine leads, the angle to which the dividing head must be set can be changed to suit conditions. All you need in addition to this instruction book is a table of sine functions.

Formula: $\frac{\text{Lead of Cam}}{\text{Lead of Table}} = \text{Sine of Angle ``D''}$

Examples:

1. Suppose you want to mill a cam having a .500″ lead. Assume change gears are set up for 2.5″ table lead.

   $\frac{\text{Lead of Cam}}{\text{Lead of Table}} = \frac{.5}{2.5} = .200$; sine of angle "D".

   "D" = 11 degrees, 33 min.

2. Suppose you want to mill a lead of 6.005″.

   (a) Assume change gears are set up for 8″ table lead.

   $\frac{\text{Lead of Cam}}{\text{Lead of Table}} = \frac{6.005}{8} = .7506$; Angle "D" = 48 degrees, 39 min.

   (b) Assume change gears are set up for 9.935″ table lead, instead of 8″, as in example 2a, then

   $\frac{6.005}{9.935} = .6044$; and Angle "D" = 37 degrees, 11 min.

ACCESSORIES AND ATTACHMENTS

HIGH NUMBER INDEXING ATTACHMENT

This attachment, shown in Figure 70, consists of three plates, drilled on both sides. These plates are interchangeable with the standard index plate on the side of the head. Those for the standard Dividing Head may also be applied to Spiral Milling Heads and Gear Cutting Attachments.

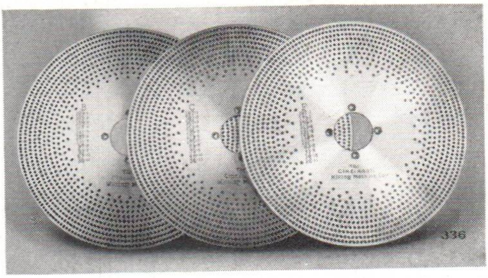


Figure 70
High Number Indexing Attachment

High Number Index Plates are also available for the Wide Range Divider. These are recommended only where the compensating feature is objectionable for numbers below 200.

The index table shown on pages 106-107, apply to the High Number Indexing Attachment Plates tabulated below.

Number of Holes Drilled in Each Side of High Number Index Plates

For Standard Dividing Head					
Part No. 10525		Part No. 10526		Part No. 10527	
For Wide Range Divider					
Part No. 113505		Part No. 113506		Part No. 113507	
Side A	Side B	Side C	Side D	Side E	Side F
189	199	197	193	191	187
177	183	181	179	175	173
171	169	167	163	161	159
147	157	153	151	149	143
129	141	139	137	133	131
117	127	123	121	119	113
99	111	109	107	103	101
91	97	93	89	87	83
69	81	79	77	73	71
48	67	46	44	42	38
30	36	34	32	26	28

COMPENSATING DOG AND DRIVER

The Compensating Dog and Driver, Figure 80, may be used with CINCINNATI Dividing Heads and Gear Cutting Heads. With these driving elements, greater accuracy will be obtained on taper work. The tail of the dog has a close fitting roller, which, in turn, fits into the slot of the driver. As the work is indexed, the roller slides on the tail of the dog a sufficient amount to compensate for the varying difference in the distance from the center of the work to the point of driving contact. The dog has a capacity range from 1/4″ to 2 3/4″ diameter.

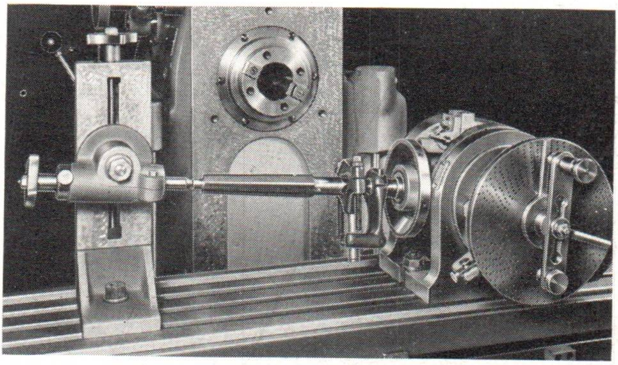


Figure 71
High Tailstock and Compensating Milling Machine Dog and Driver

HIGH TAILSTOCK

If the work has a steep angle taper and is relatively long, the High Tailstock illustrated in Figure 71 may be used to advantage. The bracket carrying the center is graduated and can be set at the same angle as the work.

Maximum distance, table to center point—11 1/32″.

Minimum distance, table to center point—3 21/32″.

RAISING BLOCKS

Raising blocks, one of which is illustrated in Figure 72A, may be placed under the Dividing Head and Tailstock to obtain an increase in range. These blocks are flat, parallel, and of equal height, (supplied only in matched pairs) and give the head and tailstock a substantial support.

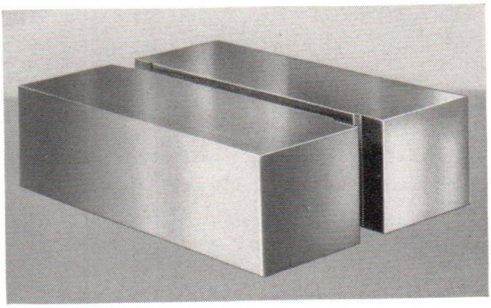


Figure 72A
Raising Block

SPECIFICATIONS

Size Head	Height of Blocks	Width T-Slots	Headstock Block		Tailstock Block	
			Length	Width	Length	Width
12″ 14″	2½″ 2″	13/16″ 13/16″	12 9/16″ 12 9/16″	9¼″ 9¼″	6⅝″ 6⅝″	6⅛″ 6⅛″

ANGLE PLATE

Angle Plates, illustrated in Figure 72B, are convenient for many types of set-ups involving a Dividing Head or small fixture placed off-center or at an angle to the table T-slots. The T-slots are standard size and at right angles to each other.

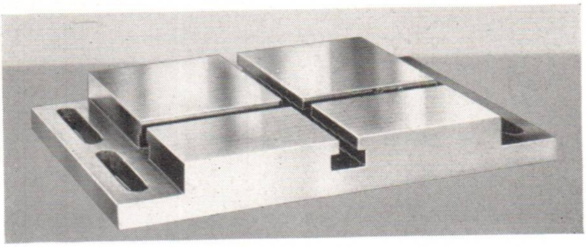


Figure 72B
Angle Plate

SPECIFICATIONS

Size Head	Height of Plate	Width T-Slot	Working Surface	Size Over All
12″ 14″	2⅛″ 2⅛″	13/16″ 13/16″	12½″ x 12⅜″ 12½″ x 12⅜″	12½″ x 16⅝″ 12½″ x 16⅜″

SPIRAL MILLING HEAD
(and Gear Cutting Attachment)

The Spiral Milling Head is shown in Figure 73. When the bracket for connecting the driving mechanism (shown at the extreme right) is omitted, the head is known as the "Gear Cutting Attachment". Of course, the type of work-piece milled on the latter attachment is limited to those requiring indexing only, such as spur gears. These heads are suitable for heavy and continuous gear cutting.

The driving mechanism for the Spiral Milling Head is similar to, but not exactly the same as the one for the Dividing Head. In other words, driving mechanism brackets are not interchangeable between Dividing Heads and Spiral Milling Heads.

All index and lead tables in this booklet apply to the Spiral Milling Head. The Index tables only (pages 105-107) apply to the Gear Cutting Attachment.

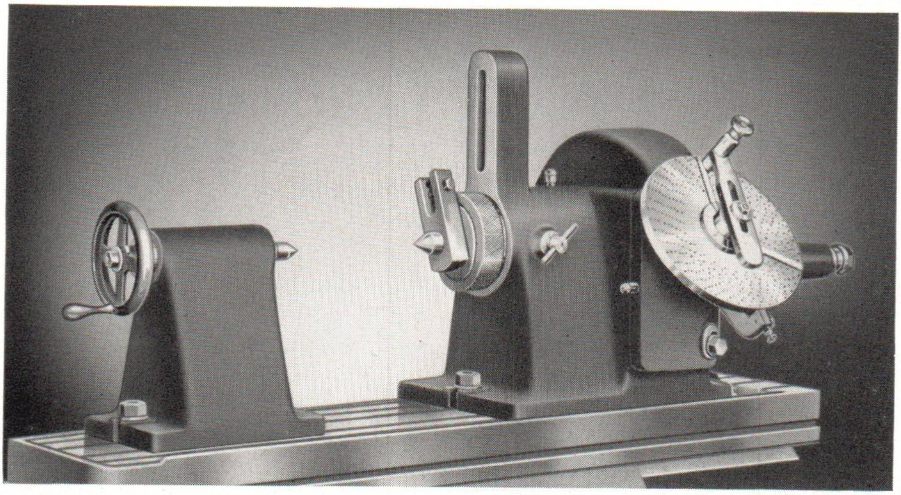


Figure 73
Spiral Milling Head

Specifications for Spiral Milling Heads and Gear Cutting Attachments

Size of Head	Actual Swing	Taper Hole in Spindle	Overall Length of Tailstock	Overall Length of Head
12″	12½″	11 B&S	9⅜″	15⅝″
16″	16⅛″	12 B&S	9⅜″	16⅝″

ARBORS—"50" Spindle Series

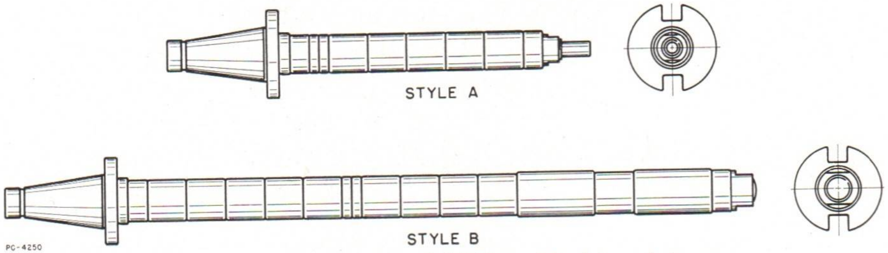


Figure 74—Conventional Milling Machine Arbors

Catalog Number	Diameter	Style	Usable Length of Cutter Space	Diameter of Bearing Collar	Size of Keyway		Code Name
					Width	Depth	
*50- ⅞A10	⅞	A	10	None	. . . .	. . . .	TENAR
*50-1 A12	1	A	12	None	¼	5/32	ARTWA
*50-1 A15	1	A	15	None	¼	5/32	ARBAA
50-1 A18-4	1	A	18	2⅛	¼	5/32	ATARB
50-1 B18-4	1	B	18	2⅛	¼	5/32	ARBFF
50-1 A18-5	1	A	18	2¾	¼	5/32	ARIUN
50-1 B24-4	1	B	24	2⅛	¼	5/32	ARBFA
50-1 B24-5	1	B	24	2¾	¼	5/32	ARATT
*50-1¼A12	1¼	A	12	None	5/16	3/16	ARBCO
*50-1¼A15	1¼	A	15	None	5/16	3/16	AROGU
50-1¼A18-4	1¼	A	18	2⅛	5/16	3/16	ARBRU
50-1¼B18-4	1¼	B	18	2⅛	5/16	11/64	BETAR
50-1¼A18-5	1¼	A	18	2¾	5/16	3/16	ARGEE
50-1¼B18-5	1¼	B	18	2¾	5/16	3/16	AREFO
50-1¼B24-4	1¼	B	24	2⅛	5/16	3/16	ONARB
50-1¼B24-5	1¼	B	24	2¾	5/16	3/16	FIARB
50-1½B18-4	1½	B	18	2⅛	⅜	13/64	HAFAR
50-1½B18-5	1½	B	18	2¾	⅜	7/32	ARZUK
50-1½B24-4	1½	B	24	2⅛	⅜	7/32	FORAR
50-1½B24-5	1½	B	24	2¾	⅜	7/32	ARVOF
50-1½B30-4	1½	B	30	2⅛	⅜	7/32	ARBTY
50-1½B30-5	1½	B	30	2¾	⅜	7/32	ARHAF
50-1½B36-4	1½	B	36	2⅛	⅜	7/32	ARGOB
50-1½B36-5	1½	B	36	2¾	⅜	7/32	ARSIX
50-2 B24-5	2	B	24	2¾	½	5/16	ARNYG
50-2 B30-5	2	B	30	2¾	½	5/16	TOARB
50-2 B36-5	2	B	36	2¾	½	5/16	ARBOS
50-2½B30-6	2½	B	30	3⅜	⅝	13/32	SIXAR
50-2½B36-6	2½	B	36	3⅜	⅝	13/32	ARBSI

*Style "A" arbors without bearing collars require the use of an arbor support bushing adapter (Catalog No. M-01 for Nos. 3 and 4 size machines, M-02 for Nos. 5 and 6 size machines), one of which is supplied with each machine.

Arbor supports supplied with the machine have bushings to accommodate 2⅛″ diameter bearing collars for Nos. 3 and 4 size machines, 2¾″ diameter collars for Nos. 5 and 6 size machines. Special arbor support bushings (available at extra cost) permit the use of arbors having 2¾″ diameter collars with Nos. 3 and 4 size machines, 3⅜″ diameter collars with Nos. 5 and 6 machines.

SHELL END MILL ARBORS—Style C

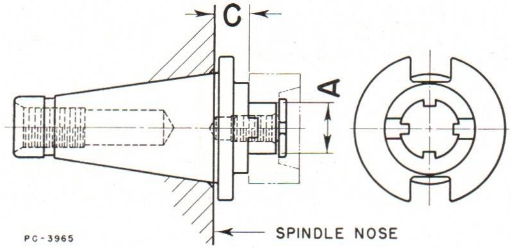


Figure 75A
Shell End Mill Arbor

Catalog Number	Diameter Range Of End Mills	Stud Diameter	Code Name
50- ½C⅝	1¼—1½	½	SHEMA
50- ¾C⅝	1¾—2	¾	SEMCO
50-1 C⅞	2¼—2½—2¾	1	SHEPU
50-1¼C⅞	3—3½	1¼	SHEBI
50-1½C⅞	4—4½—5	1½	SHEBY
50-2 C⅞	5½—6	2	SEMOR

Chrome nickel heat-treated screws for holding shell end mill on arbor are furnished with all arbors. Wrenches are furnished with arbors 50-1¼C⅞, 50-1½C⅞, and 50-2C⅞.

QUICK CHANGE ADAPTER

Catalog No. NS-H5 **Code Word — ADACO**

The use of the Quick Change Adapter in conjunction with Quick Change Shell End Mill Arbors and Quick Change Collets permits simplified interchange of cutters when a variety of different operations are required on the same job. Each of the tools required can be mounted in a separate arbor or collet and arranged on a bench or rack in the same sequence in which the operations are to be performed. The complete attachment consists of: nut, slotted key, stop lug, spanner wrench, screw for slotted key, ring, four screws, and socket wrench (see Figure 76).

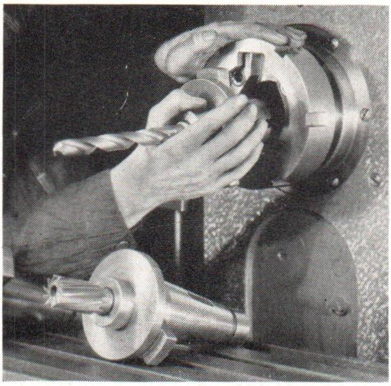


Figure 75B
Quick Change Adapter, and Quick Change Arbors and Collets Simplify Cutter Changes

QUICK CHANGE SHELL END MILL ARBORS

Catalog Number	Diameter Mills	Stud Diameter	Code Name
50- ½ FC ⅝	1¼—1½	½	ARABB
50- ¾ FC ⅝	1¾—2	¾	ARDUI
50-1 FC ⅞	2¼—2½—2¾	1	ARSHE
50-1¼ FC ⅞	3—3½	1¼	ARTTA
50-1½ FC ⅞	4—4½—5	1½	ARICK
50-2 FC ⅞	5½—6	2	AREMI

QUICK CHANGE COLLETS

(Includes Draw-in Bolt)

Catalog Number	Style	Inside Taper	Code Name
50-NS-FEB 7	B	No. 7 B. & S.	COQUI
50-NS-FEB 9	B	No. 9 B. & S.	COSEM
50-NS-FEB 10	*A	No. 10 B. & S.	COSBE
50-NS-FEB 11	B	No. 11 B. & S.	COTTO
50-NS-FEM 2	B	No. 2 Morse	CORIC
50-NS-FEM 3	B	No. 3 Morse	COROB
50-NS-FEM 4	B	No. 4 Morse	CODDE

*Style A does not have nose extending beyond flange face.

Instructions for Mounting Quick Change Adapter on Spindle Nose

1. Rotate the spindle until the driving keys line up parallel with the table. Remove the right-hand key, and insert in its place the special key and stop lug, with the long end of the stop lug extending beyond the circumference of the spindle. (See sketch, Figure 76).

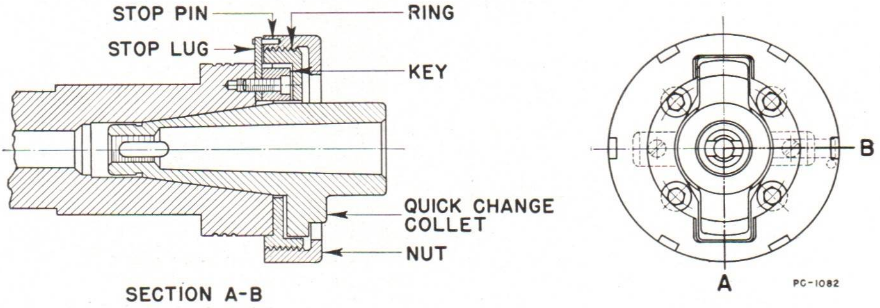


Figure 76
Section Through Quick Change Adapter

2. Assemble the nut on the ring by screwing these two parts together. The rear face of the ring (with the 1″ wide slots) should be approximately flush with the rear face of the nut, and at the same time the key openings in these two parts should match.

3. Place the ring and nut as assembled in step No. 2 on the face of the machine spindle, with the stop pin directly below the stop lug. The nut can now be turned from this position in a clockwise direction only.

4. Now fasten the assembly, as described in step No. 3, to the spindle nose with the four hollow hexagon head screws which are furnished with the complete adapter. In order to accomplish this, turn the nut as required so that the screws can be inserted.

5. The quick change adapter is now ready for use. The operations are as follows:
    a. Turn the adapter nut counter-clockwise until the stop pin hits the stop lug.
    b. Insert the quick change arbor or collet, as the case may be.
    c. Turn the nut clockwise and tighten with a spanner wrench.

QUICK CHANGE FACE MILL ARBOR

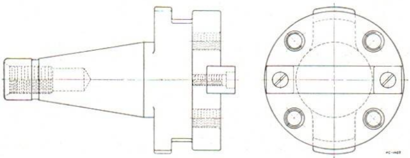


Figure 77A
Sketch of quick change face mill arbor.
For face mills 7″ to 12″ diameter.

Catalog No. . . . . 50-5$\frac{1}{16}$FC
Code Name. . . . . ARFAC

COLLET ADAPTER
Reducing No. 50 to No. 40 Spindle Series

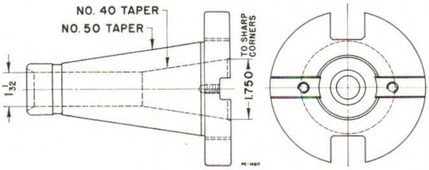


Figure 77B
Arbors and cutters having No. 40 series standard taper shanks may be used on Dial Types with the above adapter.

Outside Taper. . . . . No. 50 Milling Machine Standard
Inside Taper. . . . . No. 40 Milling Machine Standard
Catalog No. 50-NS-40 Code Name — COAFD

HOW TO STORE, HANDLE, AND USE ARBORS

The ability of a milling machine to produce accurate work in quantity or toolroom lots is dependent upon the arbor and related accessories. If the arbor is improperly stored, mis-handled, or carelessly used, both the quantity and quality of the work produced will be adversely affected. Arbors are precision tools and should be treated with much the same care as given to micrometers, vernier gages, etc. The following paragraphs deal with the proper storage, handling, and usage of arbors.

Storage. When the arbors are not in use, they should be stored in or near the milling department. There are three good methods of storing arbors in order to prevent damage or injury to them: (1) hanging vertically in a rack; (2) placed horizontally on V-supports in cabinet drawers or (3) placed vertically in a rack with the tapered end down.

The first method requires a wooden rack built to accommodate several arbors. The rack should be substantially built, strong enough to support its entire complement of arbors. Also, it should be securely anchored in place so there is no danger of the rack falling and thereby damaging the arbors. With an arbor hanging vertically and supported by its flange, even the heaviest can be easily removed by inserting an eye-bolt in the draw-in bolt hole, attaching a crane, and lifting out the arbor.

Arbor storage may also be accomplished by means of large cabinets with pull-out drawers. The drawers are of varying depths and two arbors are assigned to each drawer according to length, diameter, taper, etc. The drawer itself is so arranged as to support the arbors not only at each end of their usuable length but also at the taper and flange. Each drawer should be marked with the catalog numbers of the arbors. By using this drawer arrangement, the arbors are completely protected from grit and dirt, and the possibility of injury is decreased.

Another good way to store arbors is to build a rack in which the arbor rests on its tapered end and slightly leans toward the rear. The back of the rack should support the arbor along its full length. Side rests should also be provided to prevent the arbor from falling sideways. If desired, drawers can be provided in the bottom for storing arbor collars and other accessories.

Whichever method is used, there are a few general precautions to observe when storing the arbors:

1. Wipe the arbor and its keyway clean before storing it. Then apply a light film of oil to prevent rust.
2. If the arbor collars are kept on the arbor, wipe them clean, apply oil, and assemble.
3. Gang mills on arbors should be kept in horizontal racks. Make sure supports are provided adjacent to the cutters to prevent warping.
4. Make sure the arbor is properly supported.
5. Get someone to help you lift heavy arbors to prevent injury to yourself and the arbor.

Extra arbor collars . . . back, spacing, bearing, front . . . should be stored in suitable boxes clearly marked with their name, size, etc. After the collars are used, they should be cleaned and oiled before putting them away.

Handling. Proper handling plays an important part in the long life and accuracy of the arbor. If the arbor is mishandled . . . dropped on the floor or machine table, nicked up, keyways spread apart, etc. . . . it will not perform like the precision tool which it is.

General precautions which should be observed when handling arbors are as follows:

1. Always place arbors and accessories on surfaces which will not injure them. If they must be placed on metal, protect the arbor with rags, leather, wood blocks, etc. The ideal method is to use a hardwood board fitted on each side with a V-strip to prevent the arbor from rolling.
2. If the arbor is extremely heavy, get someone to help you lift it. You may seriously injure yourself by trying to lift too heavy an arbor. Before lifting an arbor fitted with collars, tighten the arbor nut by hand to prevent pinching your fingers between sliding collars.
3. When removing an arbor from storage be careful not to let it fall. You may nick or spring it. If the arbor is dropped, or if any mishap occurs, be sure to check the arbor for run-out before using.

4. Always place a charge-out slip for the arbor you are using. Make sure you return your arbor to its proper space. When several arbors of the same size are on hand, it is a good idea to number then 1, 2, 3, etc., so that certain ones can be used for roughing while others can be used for finishing only.
5. When handling gang mills on arbors be careful of the cutters as they are sharp. If you must handle them, protect your hands with thick rags.

Usage. Proper usage has a leading role in determining the accuracy and productive capacity of the arbor. It must be remembered that the arbor is a precision tool and must be treated as such. To illustrate the correct procedure for proper usage, let's follow an arbor from the time it is received at the machine until the job is set up and running.

When the arbor is received at the machine, it may or may not be fitted with arbor collars. If it is, remove them. Then wipe the arbor and keyway clean. Be sure to protect the arbor when setting it on a metal surface

Next, select the proper size square driving key and carefully fit it into the arbor keyway. The driving key should not fit extremely tight in the keyway because of the danger of raising burrs or damaging the keyway. For safety's sake, always drive the cutter with a key . . . never depend upon the side pressure of the arbor collars. When fitting the key, be careful not to start it crooked or you will damage the keyway thereby preventing the collars or cutters from fitting properly. File off any burrs on the key or arbor before fitting the collars.

The next step is to thoroughly clean the arbor's taper shank, flange, and the tapered hole in the spindle. These must be absolutely clean and free of even lint particles, as the smallest object will cock the arbor thereby producing inaccurate work. Then insert the tapered shank into the spindle hole, carefully fitting the spindle drive keys in the arbor key-slots. If possible have someone insert the draw-in bolt from the rear and screw it in two or three turns. Then screw it in the rest of the way and lock with the lock nut provided. It is a good idea to check the arbor for concentricity with an indicator by slowly rotating the machine spindle.

Carefully clean each individual back and spacing collar and assemble them on the arbor. The back collar is placed adjacent to the arbor flange to prevent arbor warpage or run-out. Make sure the faces of each collar are particularly clean, as even the smallest particle will cock the collar and consequently spring the arbor when the arbor nut is drawn up tight. Of course, the cutters are also placed on the arbor. They should be mounted as close to the spindle as operating conditions will permit.

When using the Style "B" arbors, clean the bearing collar and assemble it on the arbor. Apply a light film of oil over its entire surface. Always drive the bearing collar with a key.

The next step, for both arbor styles, is to assemble the front collar and arbor nut on the end of the arbor. A front collar must be placed on the arbor before assembling the arbor nut.

Never tighten the arbor nut directly against a bearing or spacing collar as pick-up between the collar and nut will result. Tighten the arbor nut *slightly* with your hands. At no time should the arbor nut be tightened with a wrench until the arbor support is mounted over the arbor collar or pilot end.

Then mount the arbor support on the overarm and tighten its clamping nuts. Start the spindle revolving slowly and move the arbor support over the bearing collar (Style "B") or pilot end (Style "A"), as the case may be, by means of the overarm pilot wheel. Securely tighten the overarm clamping nuts and the arbor clamping nut.

A few general precautions to observe while the machine is in operation are as follows:

1. Don't rapid traverse into the cutter. You will spring the arbor and possibly break the cutter.

2. Lubricate the bearing collar thoroughly by filling the oil reservoir in each arbor support. With proper lubrication, the possibility of the bearing collar freezing and thereby twisting the arbor is eliminated.

3. Keep all parts of your body away from rotating cutters. Don't even brush chips away with a brush while the cutter is running. The coolant nozzle should be positioned so as to wash away the chips. A rotating cutter can grab the brush and severely injure your hand before you have time to jerk it away.

4. Make sure the work is properly clamped. If the work is loosely held it will raise up and probably spring or otherwise damage the arbor.

5. Make sure all projecting parts of the fixture and work will clear the arbor, arbor support, column, etc. To check for interference, hand feed the table, fixture, and work past the stationary cutter. It should be remembered that if the projection just passes underneath the arbor, that the distance from the arbor to the work piece must be decreased by an amount equal to the depth of cut.

After the job has been completed, remove the arbor from the machine. To avoid springing, loosen the arbor nut *before* removing the arbor support. It should be carefully cleaned, the driving key removed, and then the arbor and collars should be oiled.

If gang mills are used and the cutters are not dull when the job is finished, it is a good idea not to loosen the arbor nut in order to retain the proper setting for the next running.

If the preceding recommendations for storage, handling, and usage are followed, your arbors will have a long life span and your milling machine's accuracy and productive ability will be increased.

Always Order Arbors by the Code Name and Catalog Number.

PLAIN AND SWIVEL VISES

The plain vise is illustrated in Figure 83A. With the exception of a swivel plate under the body, swivel vises are the same as plain vises. When ordering a vise, give width of T-slot in the table of the machine on which it is to be used.

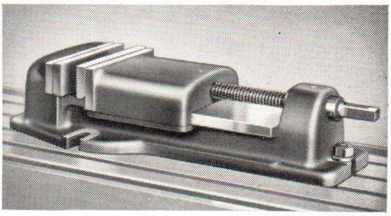


Figure 83A—Plain Vise

SPECIFICATIONS FOR PLAIN AND SWIVEL VISES

Size	Depth Jaws	Width Jaws	Jaws Open	Overall Height		Net Weight	
				Plain	Swivel	Plain	Swivel
No. 3	1⅝″	6⅛″	4″	4¼″	6″	59 lbs.	79 lbs.

ALL STEEL VISE

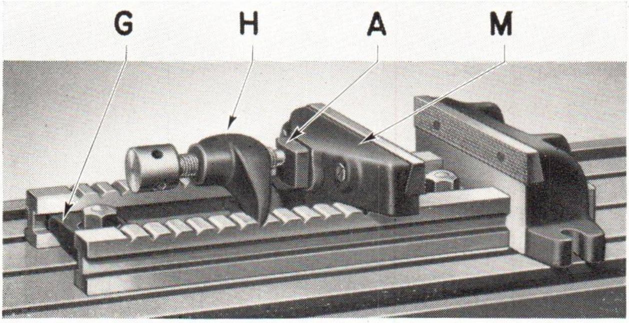


Figure 83B
All-Steel Vise

The CINCINNATI All-Steel Vise very effectively and conveniently holds heavy work, easily withstanding the most severe duty imposed on it by the machine. It can be set lengthwise or crosswise on the table. Screw holder "H", Figure 83B, and movable jaw "M" can be quickly set to give approximately the correct opening of the jaws. Plate "A" is hardened to withstand the pressure from the clamping screw. There are four clamping lugs on the solid jaw and one movable clamp "G". Jaw "M" can be swiveled, thus adapting it to the irregularities in rough castings or forgings. The jaws are serrated and hardened, assuring a firm grip on the work piece.

SPECIFICATIONS FOR ALL-STEEL VISE

Size	Distance from Table to Top of Vise Jaws	Net Weight	Shipping Weight	Code Word
10″ x 10″ x 2″	4″	80 lbs.	110 lbs.	BYVIS

TOOL MAKER'S UNIVERSAL VISE

For general tool room work. Can be swiveled in vertical plane up to and including 90 degrees—360 degrees in a horizontal plane. Maximum opening 3½″; depth of jaws 1⅝″; width of jaws 6⅛″; net weight 75 pounds.

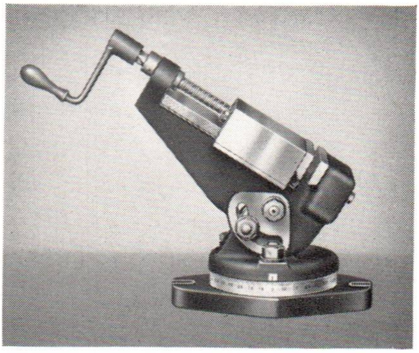


Figure 84A
Toolmaker's Universal Vise

CHUCK

Many Dividing Head jobs can be more conveniently held in a chuck than between centers. To facilitate this class of work, the 3-Jaw Universal Chuck, illustrated in Figure 84B, may be obtained. It has a threaded flange for mounting it on the spindle nose of the head.

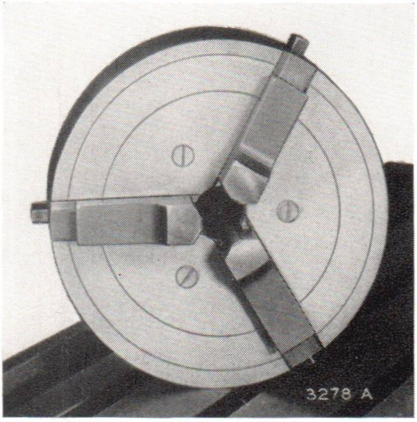


Figure 84B
Dividing Head Chuck

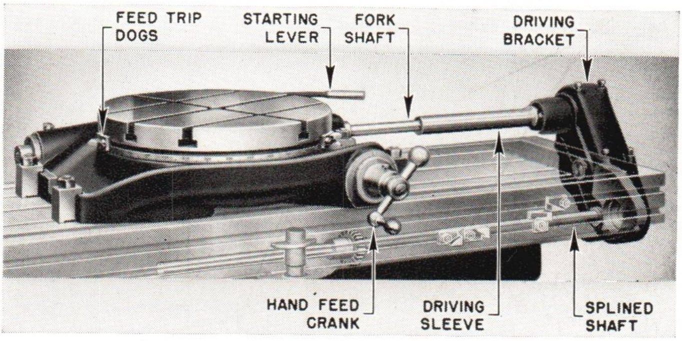
SPECIFICATIONS

Size Head	Size Chuck	Capacity	Outside Diameter	Thread
10″ Dividing	6″	⅛″ to 2¼″	7″	2″ —8 thd.
12″ Spiral	6″	⅛″ to 2¼″	7″	2½″—6 thd.
12″ Dividing 12″ Spiral	9″	¼″ to 3⅛″	9 15/16″	2½″—6 thd.

Mounting a Chuck on the Dividing Head. Before mounting a chuck on the Dividing Head spindle, remove the front index plate, Figure 64A. This step is necessary to be sure that the chuck adapter has a square fit on the spindle.

CIRCULAR MILLING ATTACHMENTS

Figure 85
20″ Circular Milling Attachment Arranged for Power Feed



Circular Milling Attachments are built in three sizes, 16″, 20″, and 24″ diameter tables. The attachment shown in the illustration, Figure 85, is a 20″ size, equipped with power feed. Hand feed attachments are essentially the same except that the driving bracket at the right-hand end of the milling machine table is not supplied.

To set up the Circular Milling Attachment with power feed mechanism, proceed in the following manner:

1. Clean the milling machine table and the bottom of the circular milling attachment.
2. Mount the attachment in the center slot of the table about midway between the ends.
3. Remove the bell-shaped cover at the right-hand end of the table.
4. Remove the hexagon head screw from the end of the spline shaft bearing in the power driving bracket. (Also remove the spline shaft if it has been left in the driving bracket from previous use.)
5. Assemble the driving bracket to the right-hand end of the table with the screws provided, and at the same time slip the driving sleeve from the bracket over the fork shaft from the attachment (or vice-versa if the shaft and sleeve are reversed).
6. Insert the splined shaft in its bearing and push it through until the shoulder rests against the end of the bearing. The other end of the shaft is then engaged in the driving gear. Try by hand to see that it turns without binding.
7. Replace the hexagon head screw in the end of the spline shaft bearing to keep the spline shaft in position.
8. The attachment is now ready to use, either with hand feed or power feed rotary motion. For conventional circular milling, the machine feed levers must be in neutral position and the machine table should be locked in position with the table clamping screws provided for this purpose. For milling scrolls or cams, disregard these two requirements.

Starting and stopping the attachment should always be performed by means of the lever at the rear of the attachment housing. This is labeled "Starting Lever" (see Figure 85).

To obtain *power rapid traverse* to the circular table, engage the conventional machine rapid traverse lever and then engage the attachment starting lever.

The actual feed rate obtained with the circular milling attachment depends upon two factors, one, diameter of work and two, table feed setting. For example, if the machine feed dial indicates 3½″ per minute, you probably will not be obtaining this feed rate on the work unless the diameter happens to be exactly right

The tables on pages 88 to 91 list the actual feeds obtained, corresponding to the indicated feed and the diameter of the work to be milled. The tables should be used in this manner—Suppose you have a 20″ attachment on the machine with an 8″ diameter work piece, and you desire to use a feed of about 4½″ per minute. Under 8″ diameter follow down the 20″ column until you come to 4.40 and then follow to the left and you will see that you should set the table feed for 3¼″ per minute.

Adjustment for the 20″ and 24″ Attachment. Cincinnati Circular Milling Attachments are provided with means of adjustment for wear between the worm and the worm-wheel.

If this adjustment is necessary on the 20″ and 24″ sizes, proceed as follows:

1. Remove the hand crank and micrometer dial.
2. Take up the end play of the worm by tightening the adjusting nut. (The worm of the 20″ and 24″ attachments is provided with ball thrust bearings for absorbing the end thrust when making heavy cuts with power feed.)

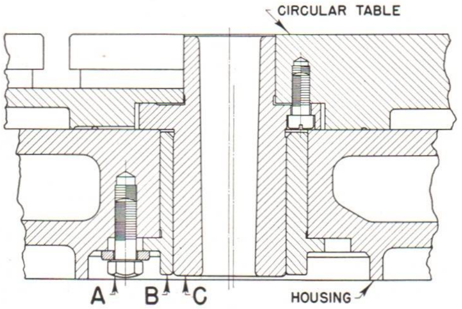


Figure 86
Section Through Eccentric Adjusting Bushing

3. Replace the micrometer dial and hand crank.
4. Loosen the two hex head screws "A-A" from the bottom of the housing. (Figure 86).
5. Turn the eccentric bushing "B" until there is no play between the worm and worm-wheel. (The sleeve "C" and the worm-wheel are bolted to the circular table and move as a unit in a straight line when the eccentric bushing "B" is turned.)
6. Retighten screws "A-A".

Do not make the adjustment so tight as to prohibit free movement of the circular table with the hand crank.

Adjustment for 16″ Attachment. To adjust for wear between the worm and worm-wheel of the 16″ attachment proceed as follows:

1. Loosen screw "B" (Figure 87A).
2. Move lever "A" to the left beyond the upper pin hole, fully engaging the worm with the worm-wheel.
3. Tighten screw "B".
4. Loosen screw "C" and turn lever "A" to the right until the pin falls into the upper hole.
5. Retighten screw "C".

Do not make the adjustment so tight as to prohibit free movement of the circular table by means of the hand-wheel.

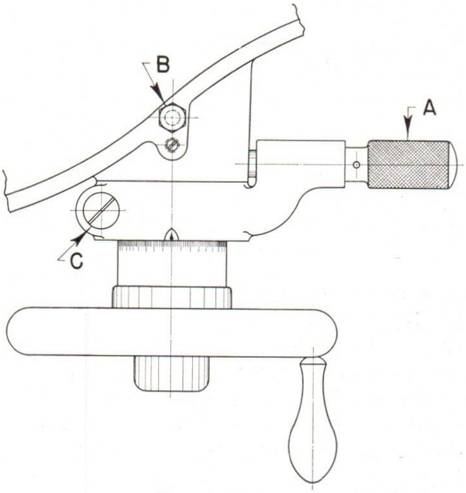


Figure 87A
Worm Adjustment for 16″ Attachment

Circular gibs are provided to take up the wear between the circular table and housing. To make this adjustment proceed as follows:

1. Remove the four set screw "A" from the bottom of the housing. (Figure 87B).
2. Tighten each gib adjusting screw "B" the same amount until there is no play in the table. Try table rotation by hand after each screw adjustment.
3. Replace set screws "A". Try table rotation by hand. It must rotate smoothly.

The two ½″ hexagon nuts located between the four set screws are for clamping the table in position.

The driving worm of the 16″ attachment may be entirely disengaged from the worm wheel by moving lever "A" (Figure 87A to the right until the pin falls into the lower pin hole. The table is then free to revolve independently of the worm.

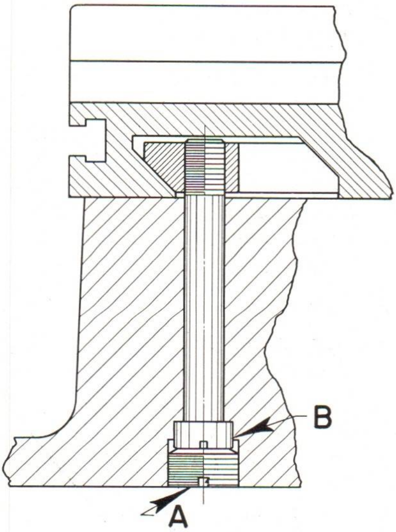


Figure 87B
Gib Adjustment for 16″ Attachment

FEEDS OBTAINED ON CIRCULAR MILLING ATTACHMENTS CORRESPONDING TO DIAMETER OF WORK AND INDICATED FEED—FOR ¼″-60″ PER MIN. FEED RANGE

	Dia. Work→	1″		2″		3″		4″		5″		6″		7″		8″		9″	
	Size Attach.→	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″
INDICATED TABLE FEED RATE	¼	.028	.042	.057	.084	.078	.126	.113	.168	.142	.210	.170	.253	.199	.295	.227	.337	.255	.379
	5/16	.035	.053	.071	.106	.106	.158	.142	.221	.177	.263	.213	.316	.248	.368	.284	.422	.319	.474
	⅜	.043	.063	.085	.127	.128	.190	.170	.253	.212	.316	.256	.379	.298	.442	.341	.506	.383	.568
	7/16	.050	.074	.099	.148	.149	.221	.198	.295	.248	.368	.298	.443	.348	.516	.398	.590	.447	.665
	½	.057	.084	.114	.169	.170	.253	.227	.337	.284	.421	.340	.506	.397	.590	.454	.675	.510	.758
	⅝	.071	.105	.142	.211	.213	.316	.284	.421	.354	.526	.426	.632	.497	.737	.568	.843	.638	.948
	¾	.085	.126	.170	.253	.256	.379	.340	.505	.425	.632	.511	.759	.596	.884	.682	1.02	.766	1.14
	⅞	.099	.148	.199	.296	.298	.442	.397	.590	.496	.737	.596	.885	.695	1.06	.795	1.18	.894	1.33
	1 1/16	.122	.179	.242	.358	.362	.537	.482	.716	.603	.895	.725	1.07	.845	1.25	.967	1.43	1.08	1.61
	1¼	.142	.211	.284	.422	.426	.633	.568	.843	.709	1.05	.852	1.26	.993	1.47	1.14	1.69	1.27	1.90
	1½	.170	.253	.340	.506	.511	.759	.681	1.01	.851	1.26	1.02	1.52	1.19	1.77	1.36	2.02	1.53	2.28
	1¾	.199	.295	.397	.590	.596	.885	.795	1.18	.993	1.48	1.19	1.77	1.39	2.06	1.59	2.36	1.79	2.68
	2⅛	.241	.358	.482	.717	.724	1.07	.965	1.43	1.21	1.79	1.45	2.15	1.69	2.51	1.93	2.87	2.17	3.22
	2½	.284	.421	.568	.843	.852	1.27	1.13	1.69	1.42	2.11	1.70	2.53	1.99	2.95	2.27	3.37	2.55	3.79
	3	.340	.505	.680	1.01	1.02	1.52	1.36	2.02	1.70	2.53	2.04	3.03	2.38	3.54	2.73	4.04	3.06	4.55
	3½	.397	.590	.795	1.18	1.19	1.77	1.59	2.36	1.98	2.94	2.38	3.54	2.78	4.13	3.18	4.72	3.58	5.31
	4¼	.482	.716	.965	1.43	1.45	2.15	2.04	2.86	2.41	3.58	2.90	4.30	3.38	5.01	3.86	5.73	4.33	6.45
	5	.567	.843	1.14	1.69	1.70	2.53	2.27	3.37	2.84	4.21	3.40	5.06	3.97	5.90	4.54	6.74	5.10	7.58
	6¼	.709	1.05	1.42	2.11	2.13	3.16	2.84	4.21	3.54	5.26	4.26	6.32	4.97	7.37	5.68	8.43	6.38	9.48
	7½	.851	1.26	1.70	2.53	2.56	3.79	3.40	5.05	4.25	6.31	5.11	7.59	5.96	8.85	6.81	10.2	7.66	11.4
	8¾	.993	1.48	1.99	2.96	2.98	4.42	3.97	5.90	4.96	7.36	5.96	8.85	6.95	10.6	7.95	11.8	8.94	13.3
	10	1.13	1.68	2.26	3.36	3.40	5.06	4.54	6.74	5.67	8.43	6.81	10.1	7.94	11.8	9.09	13.5	10.2	15.2
	12	1.36	2.02	2.73	4.04	4.08	6.07	5.45	8.09	6.81	10.1	8.18	12.1	9.54	14.2	10.9	16.2	12.3	18.2
	14½	1.65	2.44	3.29	4.89	4.94	7.33	6.58	9.78	8.23	12.2	9.88	14.7	11.5	17.1	13.2	19.6	14.8	22.0
	18	2.04	3.03	4.08	6.07	6.13	9.10	8.17	12.1	10.2	15.2	12.3	18.2	14.3	21.2	16.4	24.3	18.4	27.3
	21½	2.44	3.62	4.88	7.25	7.33	10.9	9.76	14.5	12.2	18.1	14.6	21.8	17.1	25.4	19.6	29.0	21.9	32.6
	26	2.95	4.38	5.90	8.77	8.85	13.2	11.8	17.5	14.7	21.9	17.7	26.3	20.6	30.6	23.6	35.1	26.6	39.4
	31	3.52	5.22	7.04	10.4	10.6	15.7	14.1	20.9	17.6	26.1	21.1	31.4	24.6	36.6	28.2	41.8	31.6	47.0
	36	4.08	6.07	8.17	12.1	12.3	18.2	16.3	24.2	20.4	30.3	24.5	36.4	28.6	42.4	32.7	48.5	36.8	54.6
	42	4.77	7.07	9.53	14.2	14.3	21.2	19.1	28.3	23.8	35.4	28.6	42.5	33.4	49.5	38.2	56.6	42.8	63.7
	50	5.67	8.43	11.4	16.9	17.0	25.3	22.7	33.7	28.3	42.1	34.0	50.6	39.7	59.0	45.4	67.5	51.1	75.8
	60	6.81	10.1	13.6	20.2	20.4	30.3	27.2	40.4	34.0	50.5	40.8	60.7	47.7	70.7	54.5	80.9	61.2	91.0

FEEDS OBTAINED ON CIRCULAR MILLING ATTACHMENTS CORRESPONDING TO DIAMETER OF WORK AND INDICATED FEED—FOR ¼″-60″ PER MIN. FEED RANGE

	Dia. Work→	10″		11″		12″		13″		14″		15″		16″		17″	18″	19″	20″
	Size Attach.→	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	20″ and 24″	20″ and 24″	20″ and 24″	20″ and 24″
INDICATED TABLE FEED RATE	¼	.284	.421	.312	.463	.341	.506	.369	.548	.397	.590	.426	.632	.454	.674	.716	.758	.800	.842
	5/16	.355	.527	.391	.580	.426	.632	.461	.685	.497	.737	.533	.791	.567	.843	.895	.948	1.00	1.05
	⅜	.425	.632	.468	.695	.511	.758	.553	.821	.596	.885	.648	.948	.680	1.01	1.07	1.14	1.20	1.26
	7/16	.497	.736	.546	.811	.596	.885	.645	.958	.695	1.06	.745	1.11	.795	1.18	1.25	1.33	1.40	1.47
	½	.567	.843	.624	.926	.681	1.02	.738	1.10	.794	1.18	.852	1.26	.908	1.35	1.43	1.52	1.60	1.68
	⅝	.709	1.05	.781	1.16	.852	1.27	.923	1.37	.993	1.48	1.06	1.58	1.14	1.69	1.79	1.90	2.00	2.10
	¾	.851	1.26	.936	1.39	1.04	1.52	1.11	1.64	1.19	1.77	1.28	1.90	1.36	2.02	2.15	2.27	2.40	2.52
	⅞	.993	1.48	1.09	1.62	1.19	1.77	1.29	1.92	1.39	2.06	1.49	2.22	1.59	2.36	2.51	2.65	2.80	2.95
	1 1/16	1.21	1.79	1.33	1.97	1.45	2.15	1.57	2.33	1.69	2.51	1.81	2.69	1.93	2.87	3.05	3.22	3.40	3.58
	1¼	1.42	2.11	1.56	2.32	1.70	2.53	1.84	2.74	1.99	2.95	2.13	3.16	2.27	3.37	3.58	3.79	4.00	4.22
	1½	1.70	2.53	1.87	2.78	2.04	3.04	2.22	3.28	2.38	3.54	2.56	3.79	2.72	4.04	4.30	4.55	4.80	5.06
	1¾	1.99	2.95	2.18	3.24	2.38	3.54	2.58	3.83	2.78	4.13	2.98	4.43	3.18	4.72	5.01	5.31	5.60	5.90
	2⅛	2.42	3.58	2.66	3.94	2.90	4.30	3.13	4.66	3.38	5.02	3.62	5.37	3.86	5.73	6.08	6.45	6.80	7.17
	2½	2.84	4.22	3.12	4.63	3.40	5.06	3.69	5.47	3.97	5.90	4.26	6.32	4.54	6.74	7.16	7.58	8.00	8.42
	3	3.40	5.06	3.74	5.56	4.08	6.07	4.43	6.57	4.77	7.08	5.11	7.58	5.45	8.08	8.60	9.10	9.60	10.1
	3½	3.97	5.90	4.37	6.49	4.77	7.08	5.16	7.67	5.56	8.25	5.96	8.85	6.35	9.44	10.1	10.6	11.2	11.8
	4¼	4.82	7.16	5.30	7.88	5.79	8.60	6.27	9.31	6.75	10.0	7.24	10.8	7.72	11.5	12.2	12.9	13.6	14.3
	5	5.67	8.43	6.24	9.27	6.81	10.2	7.38	11.0	7.94	11.8	8.51	12.6	9.08	13.5	14.3	15.2	16.0	16.8
	6¼	7.09	10.5	7.80	11.6	8.52	12.6	9.22	13.7	9.93	14.7	10.6	15.8	11.4	16.9	17.9	19.0	20.0	21.0
	7½	8.51	12.6	9.36	13.9	10.4	15.2	11.1	16.4	11.9	17.7	12.8	19.0	13.6	20.2	21.5	22.7	24.0	25.2
	8¾	9.92	14.8	10.9	16.2	11.9	17.7	12.9	19.2	13.9	20.6	14.9	22.2	15.9	23.6	25.1	26.5	28.0	29.5
	10	11.3	16.8	12.5	18.5	13.6	20.2	14.7	21.9	15.9	23.6	17.0	25.3	18.1	26.9	28.6	30.3	32.0	33.7
	12	13.6	20.2	15.0	22.2	16.4	24.3	17.7	26.3	19.1	28.3	20.4	30.4	21.8	32.4	34.4	36.4	38.4	40.4
	14½	16.4	14.4	18.1	26.8	19.8	29.3	21.4	31.8	23.0	34.2	24.7	36.7	26.3	39.1	41.5	44.0	46.4	48.8
	18	20.4	30.3	22.5	33.4	24.5	36.4	26.6	39.4	28.6	42.4	30.6	45.5	32.7	48.5	51.5	54.6	57.6	60.7
	21½	24.4	36.2	26.8	39.8	29.3	43.5	31.7	47.1	34.2	50.7	36.6	54.4	39.0	58.0	61.5	65.2	68.8	72.5
	26	29.5	43.8	32.4	48.2	35.4	52.6	38.4	56.9	41.3	61.3	44.2	65.7	47.2	70.0	74.5	78.8	83.2	87.6
	31	35.2	52.2	38.7	57.5	42.2	62.7	45.7	67.8	49.2	73.1	52.8	78.4	56.3	83.5	88.8	94.0	99.2	104
	36	40.8	60.7	44.9	66.7	49.0	72.8	53.2	78.8	57.2	84.9	61.3	91.0	65.4	97.0	103	109	115	121
	42	47.7	70.8	52.4	77.8	57.2	85.0	62.0	92.0	66.7	99.1	71.5	106	76.3	113.0	120	127	134	142
	50	56.7	84.3	62.4	92.7	68.1	101.0	73.8	110.0	79.4	118.0	85.1	127	90.8	135.0	143	152	160	168
	60	68.1	101.0	74.9	111.0	81.8	121.0	88.5	132.0	95.3	142.0	104.0	152	109.0	162.0	172	182	192	202

FEEDS OBTAINED ON CIRCULAR MILLING ATTACHMENTS CORRESPONDING TO DIAMETER OF WORK AND INDICATED FEED—FOR $\frac{3}{8}''$-90″ PER MIN. FEED RANGE

	Dia. Work→	1″		2″		3″		4″		5″		6″		7″		8″		9″	
	Size Attach.→	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″
INDICATED TABLE FEED RATE	3/8	.042	.063	.085	.126	.128	.190	.170	.253	.213	.316	.255	.380	.298	.442	.340	.506	.384	.570
	7/16	.049	.074	.099	.148	.149	.222	.198	.295	.248	.369	.298	.443	.348	.516	.398	.590	.446	.665
	9/16	.064	.095	.128	.190	.192	.285	.255	.380	.320	.475	.383	.570	.447	.663	.510	.760	.575	.855
	11/16	.078	.116	.156	.232	.234	.348	.312	.464	.390	.580	.468	.695	.547	.810	.624	.928	.700	1.04
	13/16	.092	.137	.184	.275	.277	.412	.368	.550	.462	.686	.553	.822	.647	.958	.740	1.10	.830	1.14
	15/16	.106	.158	.213	.316	.319	.475	.425	.632	.532	.790	.638	.950	.745	1.11	.850	1.26	.957	1.42
	1 1/8	.128	.190	.256	.380	.383	.570	.510	.760	.640	.950	.765	1.14	.893	1.32	1.02	1.52	1.15	1.71
	1 5/16	.149	.222	.298	.444	.446	.664	.595	.884	.744	1.10	.892	1.32	1.04	1.54	1.19	1.77	1.34	1.99
	1 5/8	.184	.275	.370	.550	.553	.822	.737	1.10	.923	1.37	1.11	1.64	1.29	1.92	1.48	2.20	1.66	2.47
	1 7/8	.213	.316	.426	.632	.638	.950	.850	1.26	1.32	1.58	1.28	1.89	1.49	2.21	1.70	2.53	1.92	2.85
	2 1/4	.255	.380	.510	.760	.767	1.14	1.02	1.52	1.28	1.90	1.53	2.27	1.78	2.66	2.04	3.04	2.30	3.41
	2 5/8	.298	.443	.596	.886	.893	1.33	1.19	1.77	1.49	2.22	1.78	2.66	2.08	3.10	2.38	3.54	2.68	3.98
	3 1/4	.369	.548	.738	1.10	1.11	1.65	1.47	2.19	1.85	2.75	2.22	3.29	2.58	3.84	2.95	4.40	3.32	4.94
	3 3/4	.425	.633	.850	1.27	1.28	1.90	1.70	2.53	2.13	3.16	2.55	3.80	2.98	4.43	3.40	5.07	3.83	5.70
	4 1/2	.510	.760	1.02	1.52	1.53	2.28	2.04	3.04	2.55	3.80	3.06	4.55	3.57	5.32	4.09	6.08	4.60	6.83
	5 1/4	.596	.885	1.19	1.78	1.79	2.66	2.38	3.54	2.98	4.43	3.58	5.32	4.17	6.20	4.77	7.08	5.36	7.98
	6 1/2	.736	1.10	1.48	2.20	2.21	3.29	2.94	3.40	3.69	5.48	4.43	6.58	5.17	7.67	5.90	8.78	6.64	9.88
	7 1/2	.850	1.26	1.70	2.53	2.55	3.80	3.40	5.06	4.26	6.32	5.10	7.58	5.96	8.85	6.80	10.1	7.66	11.4
	9	1.02	1.52	2.04	3.04	3.06	4.56	4.08	6.08	5.12	7.60	6.12	9.10	7.15	10.6	8.18	12.8	9.20	13.6
	11	1.25	1.86	2.50	3.72	3.74	5.58	4.98	7.42	6.24	9.28	7.48	11.1	8.73	13.0	10.0	14.8	11.2	16.7
	13	1.48	2.19	2.96	4.39	4.42	6.58	5.90	8.77	7.38	11.0	8.84	13.2	10.3	15.3	11.8	17.5	13.3	19.7
	15 1/4	1.73	2.58	3.46	5.15	5.20	7.73	6.90	10.3	8.66	12.8	10.4	15.4	12.1	18.0	13.8	20.6	15.6	23.2
	19	2.15	3.20	4.32	6.40	6.47	9.62	8.60	12.8	10.8	16.0	12.9	19.2	15.1	22.4	17.3	25.6	19.4	28.8
	22	2.50	3.72	5.00	7.44	7.48	11.1	9.96	14.8	12.5	18.6	15.0	22.2	17.5	26.0	20.0	29.6	22.5	33.4
	27	3.06	4.55	6.12	9.10	9.20	13.7	12.2	18.2	15.3	22.8	18.4	27.3	21.4	31.8	24.5	36.5	27.5	41.0
	31	3.52	5.24	7.04	10.5	10.5	15.7	14.0	20.9	17.6	26.2	21.1	31.4	24.7	36.6	28.2	41.8	31.7	47.0
	39	4.42	6.58	8.86	13.2	13.3	19.8	17.7	25.3	22.2	32.9	26.5	39.5	31.0	46.0	35.4	52.6	39.8	59.2
	45	5.10	7.60	10.2	15.2	15.3	22.8	20.4	30.3	25.6	38.0	30.6	45.5	35.8	53.0	40.8	60.8	46.0	68.3
	54	6.10	9.10	12.3	18.2	18.4	27.3	24.5	36.5	30.7	45.5	36.7	54.6	42.9	63.7	49.0	73.0	55.2	82.0
	63	7.13	10.3	14.3	21.3	21.5	31.9	28.6	42.5	35.8	53.2	42.9	63.8	50.0	74.3	57.2	85.0	64.3	95.8
	79	8.95	13.3	18.0	26.7	26.9	40.0	35.8	53.4	44.9	66.7	53.8	80.0	62.8	93.0	71.8	106	81.8	120
	90	10.2	15.2	20.4	30.4	30.6	45.6	40.8	60.8	51.2	76.0	61.3	91.0	71.5	106	81.8	122	92.0	137

FEEDS OBTAINED ON CIRCULAR MILLING ATTACHMENTS CORRESPONDING TO DIAMETER OF WORK AND INDICATED FEED—FOR 3/8″-90″ PER MIN. FEED RANGE

	Dia. Work→	10″		11″		12″		13″		14″		15″		16″		17″	18″	19″	20″
	Size Attach.→	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	16″	20″ and 24″	20″ and 24″	20″ and 24″	20″ and 24″	20″ and 24″
INDICATED TABLE FEED RATE	3/8	.425	.632	.467	.696	.510	.760	.552	.822	.595	.884	.637	.950	.680	1.01	1.08	1.14	1.20	1.27
	7/16	.496	.737	.545	.812	.595	.885	.645	.960	.693	1.03	.743	1.11	.793	1.18	1.15	1.32	1.40	1.48
	9/16	.640	.950	.700	1.04	.768	1.14	.830	1.23	.892	1.33	.955	1.42	1.02	1.52	1.61	1.70	1.80	1.90
	11/16	.780	1.16	.857	1.28	.937	1.39	1.01	1.50	1.09	1.62	1.17	1.74	1.24	1.85	1.97	2.08	2.20	2.32
	13/16	.922	1.37	1.01	1.51	1.11	1.64	1.20	1.78	1.29	1.92	1.38	2.06	1.47	2.19	2.33	2.46	2.60	2.75
	15/16	1.06	1.58	1.17	1.74	1.28	1.90	1.38	2.05	1.48	2.21	1.59	2.37	1.70	2.53	2.68	2.84	3.00	3.16
	1 1/8	1.28	1.90	1.40	2.08	1.53	2.27	1.66	2.47	1.78	2.66	1.91	2.85	2.04	3.04	3.22	3.41	3.60	3.80
	1 5/16	1.49	2.22	1.64	2.43	1.78	2.65	1.93	2.87	2.08	3.10	2.23	3.32	2.38	3.54	3.76	3.97	4.20	4.43
	1 5/8	1.84	2.74	2.03	3.02	2.22	3.29	2.40	3.56	2.57	3.84	2.76	4.11	2.95	4.40	4.66	4.93	5.20	5.48
	1 7/8	2.13	3.16	2.33	3.48	2.55	3.79	2.76	4.10	2.97	4.42	3.18	4.74	3.40	5.03	5.38	5.68	6.00	6.32
	2 1/4	2.55	3.80	2.80	4.18	3.07	4.55	3.32	4.93	3.56	5.30	3.83	5.70	4.08	6.08	6.45	6.82	7.20	7.60
	2 5/8	2.98	4.42	3.27	4.88	3.57	5.30	3.87	5.75	4.16	6.20	4.46	6.63	4.76	7.10	7.52	7.95	8.50	8.85
	3 1/4	3.69	5.48	4.05	6.03	4.43	6.58	4.80	7.12	5.16	7.67	5.53	8.22	5.90	8.78	9.30	9.84	10.4	11.0
	3 3/4	4.26	6.32	4.67	6.96	5.10	7.60	5.52	8.22	5.94	8.85	6.38	9.50	6.80	10.1	10.7	11.4	12.0	12.6
	4 1/2	5.12	7.60	5.60	8.35	6.13	9.10	6.63	9.85	7.13	10.6	7.65	11.4	8.16	12.1	12.9	13.6	14.4	15.2
	5 1/4	5.96	8.86	6.54	9.75	7.15	10.6	7.73	11.5	8.32	12.4	8.92	13.3	9.50	14.2	15.0	15.9	16.8	17.7
	6 1/2	7.38	11.0	8.20	12.1	8.85	13.2	9.58	14.2	10.3	15.3	11.0	16.4	11.8	17.5	18.6	19.7	20.8	21.9
	7 1/4	8.50	12.6	9.34	13.9	10.2	15.2	11.0	16.4	11.9	17.7	12.8	19.0	13.6	20.2	21.5	22.7	24.0	25.3
	9	10.2	15.2	11.2	16.7	12.2	18.2	13.3	19.7	14.3	21.2	15.3	22.8	16.3	24.3	25.8	27.3	28.8	30.4
	11	12.5	18.6	13.7	20.4	15.0	22.2	16.2	24.1	17.4	26.0	18.7	27.8	19.9	29.7	31.5	33.4	35.2	37.1
	13	14.8	21.9	16.2	24.1	17.7	26.3	19.2	28.5	20.6	30.7	22.1	32.9	23.5	35.1	37.3	39.4	41.6	43.9
	15 1/4	17.3	25.7	19.0	28.3	21.8	30.8	22.5	33.5	24.2	36.0	25.9	38.6	27.7	41.2	43.7	46.3	48.8	51.4
	19	21.6	32.0	23.7	35.3	25.9	38.5	28.0	41.7	30.1	44.8	32.3	48.1	34.5	51.3	54.4	57.6	60.8	64.2
	22	25.0	37.1	27.4	40.9	30.0	44.5	32.4	48.3	34.9	52.0	37.4	55.7	40.0	59.3	63.0	66.7	70.4	74.3
	27	30.6	45.5	33.6	50.2	36.8	54.6	39.8	59.2	42.8	63.7	45.9	68.3	49.0	73.0	77.3	81.8	86.4	91.0
	31	35.2	52.2	38.6	57.5	42.2	62.8	45.6	68.0	49.2	73.0	52.7	78.3	56.2	83.8	88.8	94.0	99.2	104
	39	44.2	65.8	48.6	72.4	53.2	79.0	57.5	85.5	61.8	92.0	66.3	98.5	70.8	105	112	118	125	132
	45	51.0	76.0	56.2	83.5	60.7	91.0	66.3	98.5	71.3	106	76.5	114	81.5	121	129	136	144	152
	54	61.3	91.0	67.2	100	73.5	109	79.5	118	85.5	128	91.8	136	97.8	146	155	164	173	182
	63	71.5	106	78.5	117	85.8	128	93.0	138	100	148	107	159	114	170	181	191	202	212
	79	89.7	133	98.5	183	108	160	116	173	125	186	134	200	143	213	226	239	253	267
	90	102	152	112	167	122	182	133	197	143	212	153	228	163	243	258	273	288	304

MOTOR DRIVEN UNIVERSAL MILLING OVERARM ATTACHMENT

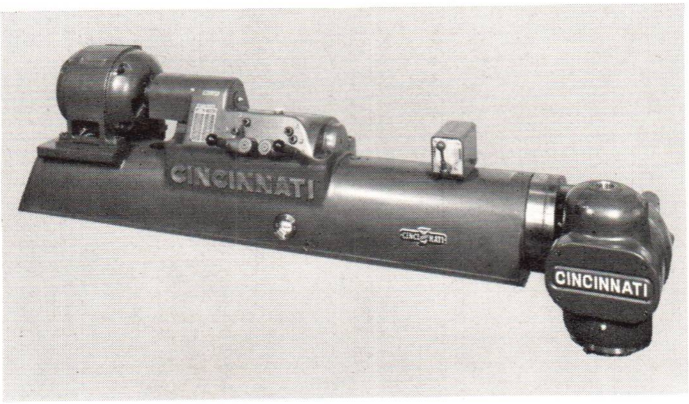


Figure 92
Motor Driven Universal Milling Overarm Attachment

This attachment, shown in Figure 92, is a completely self-contained unit built into a special overarm which replaces the standard machine overarm. Individually motor driven, the functioning of this attachment is completely independent of the machine power source. The machine spindle is free for use at any time, either independently, or in conjunction with the attachment.

Nine speeds are available, being selected by the two gear shift levers on the left side of the feed box. Two series of spindle speeds are available, selection being made at time order is placed. Low series 100 to 1030 rpm.; high series 242 to 2425 rpm. A spindle reverse switch, mounted on the forward portion of the overarm, provides instant selection of either direction of spindle rotation.

The head is carried on a pair of swivel mounts each of which can be swiveled a full 360 degrees for completely universal positioning of the spindle. A zero positioning pin is provided for each swivel.

Spindle nose is No. 50 Milling Machine Standard, the same as the machine spindle nose, thereby permitting quick interchange of cutters between attachment spindle and machine spindle. Arbor supports can be mounted and dismounted from the attachment overarm in the same manner as with the standard machine overarm, without interference from the swivel head.

This attachment can be equipped with a Hand Feed Quill Attachment, at extra cost, to permit the drilling of holes at any desired angle. The spindle of this quill mechanism is provided with a No. 7 B.&S. taper. If the attachment is equipped with this quill mechanism, and you should want to remove it from the spindle, proceed as follows:

1. Remove the cap from the top of the housing. It is held in position by several screws. Lift the cap and quill assembly from the top of the spindle.
2. A bushing and dust ring are furnished with the quill attachment as extra parts. Attach these parts and replace the cap.
3. Remove the adapter from the bottom of the spindle. The attachment is now ready to be used without the hand quill feed device.

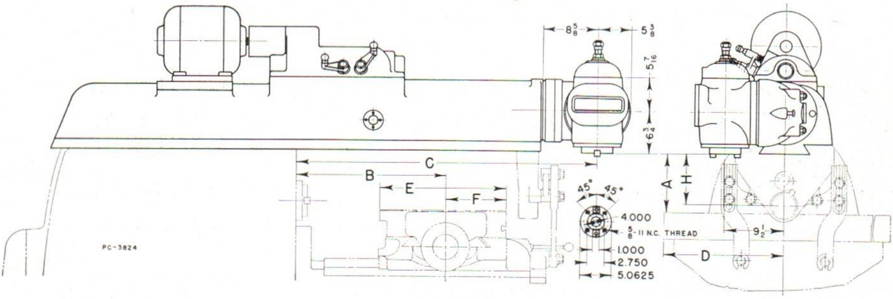


Figure 93
Dimensions—Motor Driven Universal Milling Overarm Attachment

Machine Size	A		B		C		D		E	F	H	Code Name
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.				
No. 3 High Power and Dual Power Dial Types	25½	6½	23	11	45⅛	8⅝	46 7/16	12 7/16	16	7½	6½	HZODT
No. 4 High Power and Dual Power Dial Types	26½	6½	25⅞	11⅞	49⅛	8⅝	58½	16½	18	8½	6½	HZPDT
No. 5 High Power and Dual Power Dial Types	28¼	8¼	27	13	49⅛	8⅝	69	19	20	9½	8¼	HZRDT
No. 6 High Power and Dual Power Dial Types	28¼	8¼	27	13	49⅛	8⅝	79	19	20	9½	8¼	HZRDT

*Maximum dimension "A" is for Plain Machines. Subtract one inch for Universal Machines.

HEAVY DUTY VERTICAL MILLING ATTACHMENT

This attachment will permit you to perform heavy duty vertical milling operations on a plain or universal style machine. Attachment spindle is the same size as the machine spindle to permit interchangeability of shell end mill arbors, collet adapters, etc. Spindle speeds are ⅔ spindle speed of machine. The spindle may be swiveled 90° (45° either way from the vertical) in a plane parallel to the face of the machine column.

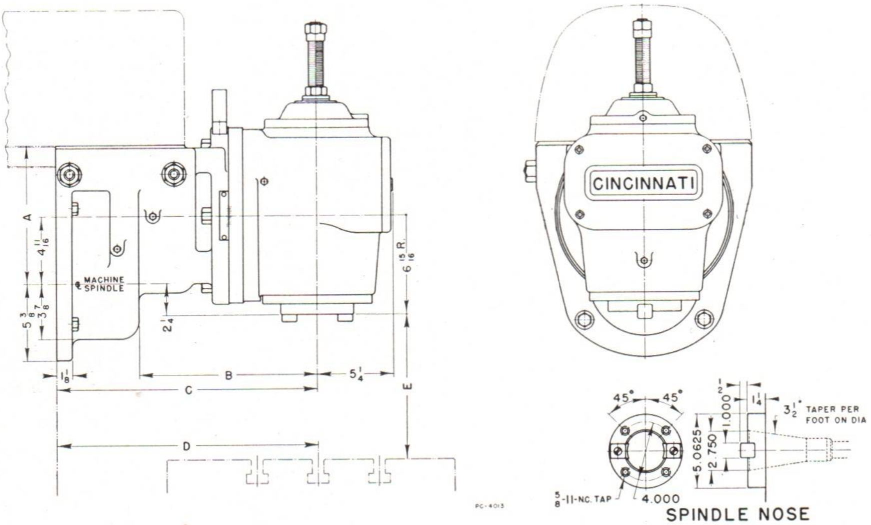


Figure 94
Dimensions—Heavy Duty Vertical Milling Attachment

Machine Size	Machine Style	A	B	C	D		E		Code Name
					Min.	Max.	Min.	Max.	
No. 3 High Power and Dual Power Dial Types	Plain	8⅝	10⅜	16⅛	11	23	½	16¼	HZJDT
	Universal	8⅝	10⅜	16⅛	11	23	½	15¼	HZJDT
No. 4 High Power and Dual Power Dial Types	Plain	8⅝	11⅜	17⅛	11⅞	25⅞	½	17¼	HZKDT
	Universal	8⅝	11⅜	17⅛	11⅞	25⅞	½	16¼	HZKDT
Nos. 5 and 6 High Power and Dual Power Dial Types	Plain	9⅝	12⅜	18⅛	13	27	½	17¼	HZLDT
	Universal	9⅝	12⅜	18⅛	13	27	½	16¼	HZLDT

HEAVY DUTY UNIVERSAL SPIRAL MILLING ATTACHMENT

This attachment will adapt your plain or universal style machine to a wide variety of milling operations requiring universal angular positioning of the cutter spindle. Attachment spindle is same size as machine spindle. Spindle speeds are 2/3 spindle speed of the machine. Each of the swivels permit full 360° adjustment so that the cutter can be positioned in any desired angular position.

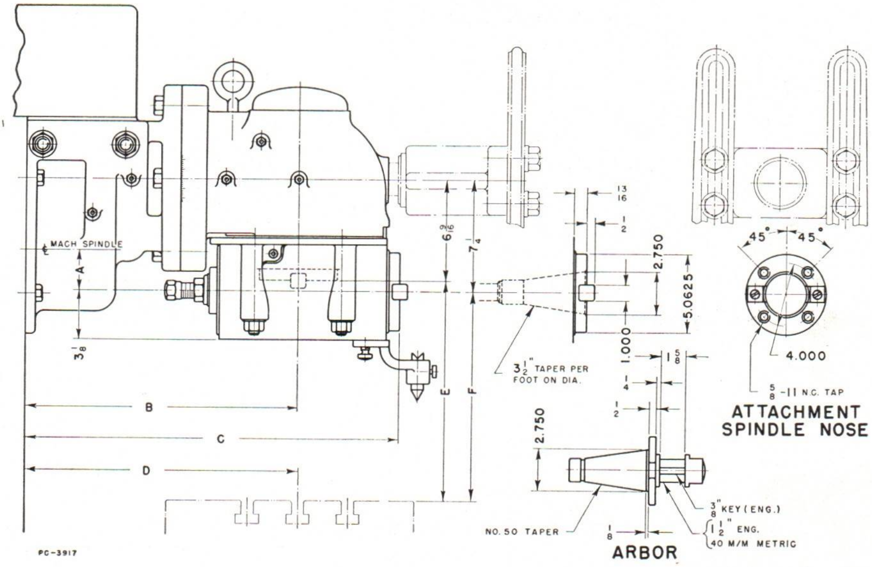


Figure 95
Dimensions—Heavy Duty Universal Spiral Milling Attachment

Machine Size	Machine Style	B	C	D				E		F		Code Name
				With Braces		Without Braces						
				Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
No. 3 High Power and Dual Power Dial Types	Plain	17 5/8	24 3/16	11	17 3/4	11	23	1/2	17 1/8	3 1/8	16 7/16	HZDDT
	Univ.	17 5/8	24 3/16	11	17 3/4	11	23	1/2	16 1/8	3 1/8	15 7/16	HZDDT
No. 4 High Power and Dual Power Dial Types	Plain	18 5/8	25 3/16	11 7/8	18 3/4	11 7/8	25 7/8	1/2	18 1/8	3 1/8	17 7/16	HZEDT
	Univ.	18 5/8	25 3/16	11 7/8	18 3/4	11 7/8	25 7/8	1/2	17 1/8	3 1/8	16 7/16	HZEDT
Nos. 5 and 6 High Power and Dual Power Dial Types	Plain	19 5/8	26 3/16	13	19 3/4	13	27	1/2	18 1/8	3 1/8	17 7/16	HZFDT
	Univ.	19 5/8	26 3/16	13	19 3/4	13	27	1/2	17 1/8	3 1/8	16 7/16	HZFDT

HIGH SPEED UNIVERSAL MILLING ATTACHMENT

This attachment provides higher speeds for use with small to medium sized cutter for jobs requiring vertical or angular positions of the cutter. These attachments are for comparatively light work and are not suitable for face milling operations.

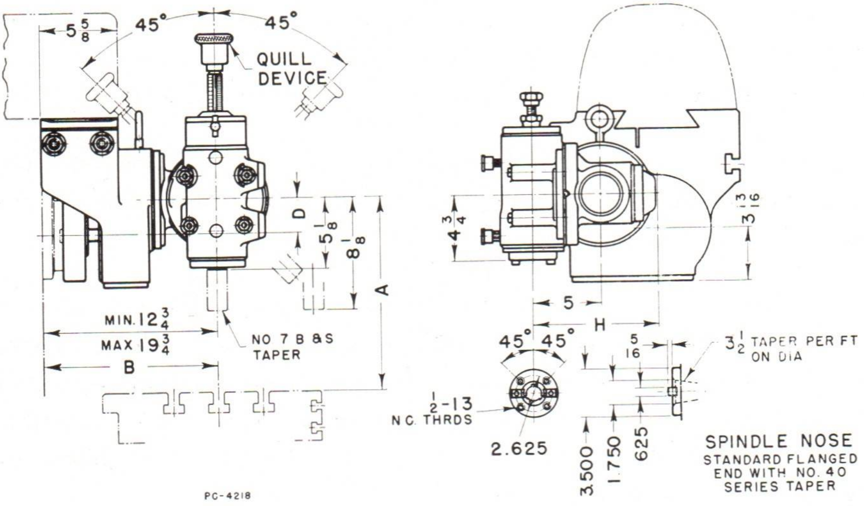


Figure 96
Dimensions—High Speed Universal Milling Attachment

TABLE OF DIMENSIONS

Machine Size	Machine Style	A		B		D	H	Code Name
		Max.	Min.	Max.	Min.			
3	Plain	17	1¼	23½	11	2 9/16	9⅛	HZVDT
	Universal	16	1¼	23½	11	2 9/16	9⅛	HZVDT
4	Plain	17 15/16	1 1/16	25⅞	11⅞	2⅜	9¼	HZVDT
	Universal	16 13/16	1 1/16	25⅞	11⅞	2⅜	9¼	HZVDT
5	Plain	17 9/16	7/16	27½	13	1¾	9 9/16	HZWDT
	Universal	16 3/16	7/16	27½	13	1¾	9 9/16	HZWDT
6	Plain	17 9/16	7/16	27½	13	1¾	9 9/16	HZWDT
	Universal	16 3/16	7/16	27½	13	1¾	9 9/16	HZWDT

The attachment is driven from the machine spindle by means of a splined shaft, fitting into an adapter mounted in the spindle nose. This method of driving provides a 7″ range of cross adjustment for the attachment, a useful feature on large work.

Spindle speeds are 1.475 x speed indicated on the machine speed dial. The spindle swivels a full 360° in a plane parallel to the face of the column, 90° (45° each way from vertical) in a plane at right angles to the face of the column. Spindle nose of attachment is No. 40 National Standard.

A Quill Hand Feed Attachment, available at extra cost, provides a 3″ axial adjustment of the cutter when this should be desired. When this device is used, the spindle nose is No. 7 B.&S.

Lubrication. The High Speed Universal Milling Attachment must be lubricated daily while in use. In the grease nipple for the lower spindle bearing, use only medium sponge short fibre grease, sodium soap base. There are three other grease nipples on the attachment proper, and one oil button in the quill feed hand knob. Periodically apply cup grease and machine oil, respectively.

Removing Quill Hand Feed Attachment. When the attachment is equipped with the quill hand feed device, and it is desirable to remove it so that cutters can be inserted in the attachment, proceed as follows:

1. Loosen the socket head, set screw in the periphery of the quill feed hand knob. Tap the screw lightly to loosen the lock shoe beneath it.
2. In the top end of the knob is a retainer nut. Remove this nut with a spanner wrench.
3. A slotted adjusting nut is now visible. Remove this nut and its lock washer.

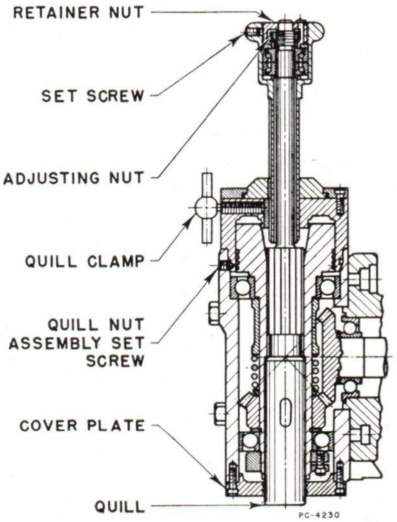


Figure 97
Section Through Attachment with Quill Hand Feed

4. Grasp the cutter shank end of the quill and pull it downward through the attachment. Replace the lock unit and washer on the quill so they will not become lost. To protect the ball bearings, also replace the retainer nut in the hand knob.
5. Remove the set screw from the body of the attachment, near the quill nut assembly.
6. Unscrew the remainder of the quill device from the body of the attachment.
7. Fit the dust cover in place and lock it with the set screw.
8. Assemble the two driving keys in the attachment spindle.
9. Remove the four screws which hold the cover plate on the housing at the rear end of the spindle, and remove the plate.
10. Drive the draw-in bolt centering bushing into the rear end of the spindle.
11. Replace the cover plate.

SLOTTING ATTACHMENT

This attachment is useful for slotting, keyway-cutting and similar operations when a slotter is not available. It mounts on the face of the column and is driven by the machine spindle. An adjustable driving crank provides adjustment of stroke length from 0″ to 4″ and a graduated scale is provided to simplify adjustments of stroke length. The tool slide can be positioned at any desired angle through a full 360 degrees, a graduated scale being provided to simplify accurate positioning. The number of strokes per minute of the tool slide is the same as the spindle speed indicated on the speed dial.

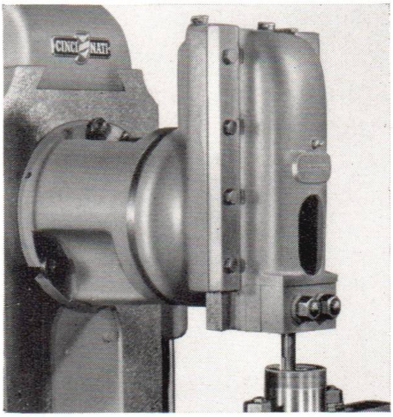


Figure 98
Slotting Attachment

RACK MILLING ATTACHMENT

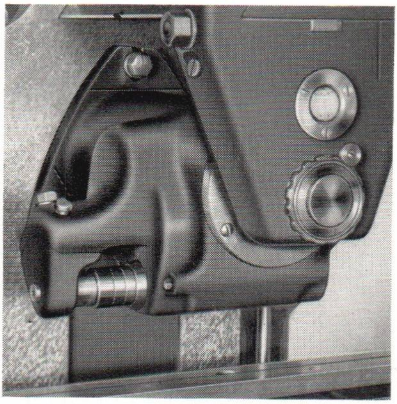


Figure 99A
Rack Milling Attachment

This attachment mounts on the face of the column and the outboard end is supported in the machine arbor support. Standard cutters fit directly on the attachment spindle and narrow slotting or side milling cutters can be used for operations which can be more conveniently performed with the machine cross feed. Two sizes of attachments are available depending upon the size cutters to be used—one has a 1¼″ diameter spindle and will take cutters up to 4¾″ diameter, the other has a 1¾″ diameter spindle and will take cutters up to 6½″ diameter. Attachment spindle speed is the same as the machine spindle speed indicated on the speed dial.

SHORT AND LONG LEAD ATTACHMENT

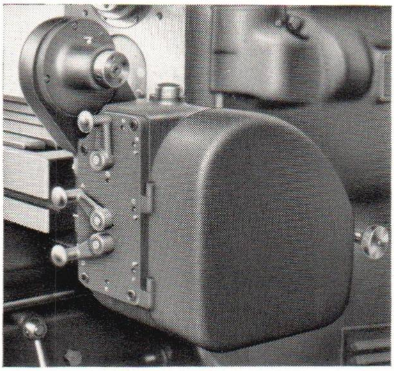


Figure 99B
Short and Long Lead Attachment

This attachment generates a wider range of leads (.010″ to 1000″) than can be generated with the standard dividing head driving mechanism (2½″ to 100″). This attachment is available, at extra cost, for universal style machines only, and should be specified when ordering the machines, as complementary parts can be built into the machine at the factory that would otherwise have to be applied in the field. Complete instructions are contained in a separate booklet "Long and Short Lead Attachment for CINCINNATI Dial Type Milling Machines". a copy of which accompanies each machine equipped with this attachment.

METHOD OF CALCULATING MACHINING TIME

The actual cutting time for milling any piece of work may be calculated from the following formula.

$$T = \frac{L + A + O}{F}$$

T = Actual Milling Time in Minutes
L = Length of Cut in Inches.
A = Approach of Cutter in Inches.
O = Over-travel of Cutter in Inches.
F = Feed in Inches per Minute.

The approach of the cutter is the distance the table must move the work into the cutter before full cutting depth or width is attained. (Dimension "A" in Figures 101A, 101B, and 102.)

The over-travel of the cutter is the distance the table must travel in power feed minus the total length of the cut. It is a safety factor to allow for variations in the length of the work piece and in clamping.

The feed is the most important factor, but there are such wide variations in feed depending upon the cutter, material, and the method of holding the work that the judgment of the set up man or operator must be relied upon to determine the correct feed. A discussion of feeds and speeds is contained in our booklet "Milling Machine Practice" a copy of which may be obtained free of charge.

Example: Suppose a cast-iron bracket is to be milled on one side, under the following conditions of feed, length of cut, etc. Calculate the actual cutting time.

Length of Cut	8″
Width of Cut	4″
Diameter of End Mill	6″
Over-travel	assume ¼″
Feed	11″ per minute

Then L = 8″
A = .77″ (See table entitled "Approach of Cutter for End Mills and Face Mills", page 102.)
O = ¼″
F = 11″

$$\text{And } T = \frac{8 + .77 + .25}{11} = .82 \text{ minutes.}$$

Total time, floor to floor = .82 + Handling Time + Time to Clear Work of Cutters.

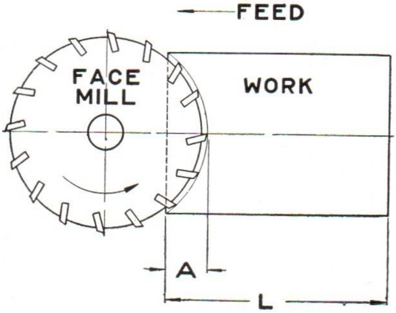


Figure 101A
Approach of Cutter (A) for Face and End Mills, with Center of Cutter Approximately in Line with Center of Work.

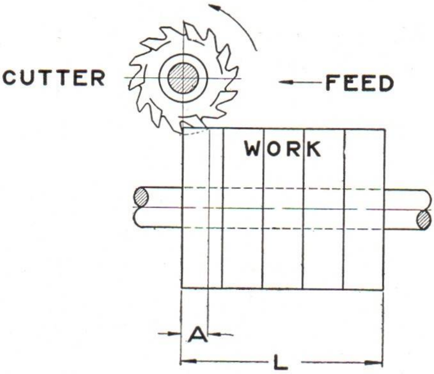


Figure 101B
Approach of Cutter (A) for Slab Milling, Keywaying, Gear Cutting, Sawing, etc.

Example: Suppose a gang of five gear blanks are to be milled between the centers of a 10″ Dividing Head, under the following conditions of feed, depth of cut, etc. Calculate the actual cutting time.

Width of Gear Face	1″
Whole Depth of Tooth	.270″
Diameter of Cutter	2¾″
Over-travel	assume ⅛″
Feed	9″ per minute

Then L = 5″ (Five gears, each 1″ wide)
A = .79″ (See table entitled "Approach of Cutter for Spiral Mills, Keyway Cutters, Saws, etc.", page 103.)
O = ⅛″
F = 9″

$$\text{And T per tooth} = \frac{5 + .79 + .125}{9} = .66 \text{ minutes}$$

Total time floor to floor:

$$= \frac{(.66 \times \text{No. of teeth}) + (\text{indexing time for one tooth} \times \text{No. of teeth} - 1).}{5}$$

$$+ \frac{\text{handling time} + \text{time to clear work of cutters.}}{5}$$

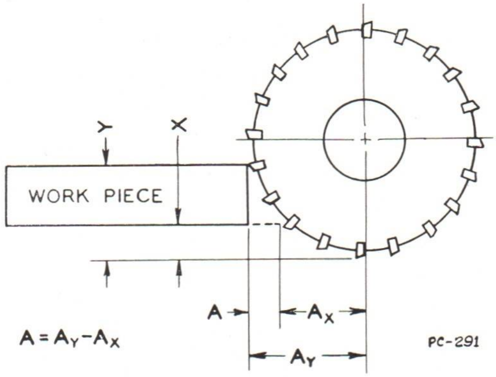


Figure 102
Approach of Cutter(A) for Face and End Mills,
with Center of Cutter Offset from Center of Work.

Example: If we have a part which requires a cut with an end mill or a face mill, and the center-line of the work does not coincide with the center of the cutter, Figure 102, the approach cannot be read directly from the table. Assuming an extreme condition, suppose we have an 8″ diameter face mill taking a 2½″ width of cut, and that one edge of the work is 1½″ from the periphery of the cutter (dimension "X" in Figure 102), while the opposite edge is 4″ from the periphery (dimension "Y" = 1½″ + 2½″). Then the approach of the cutter is the difference between the approach for a 4″ depth of cut and a 1½″ depth of cut. In the table entitled "Approach of Cutter for Spiral Mills, Keyway Cutters, Saws, etc.", the approach for an 8″ cutter at a 4″ depth is 4″, while at a 1½″ depth, it is 3.12″. The difference between 4″ and 3.12″ equals .88″, the correct approach in this particular case.

Approach of Cutter for End Mills and Face Mills

(Center of Cutter Approximately in Line with Center of Work)

Diam. of Mill	WIDTH OF CUT											
	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″
1	.5											
1½	.192											
2	.135	1.										
2½	.105	.5										
3	.09	.37	1.5									
4	.07	.27	.68	2.								
5	.05	.24	.5	1.	2.5							
6	.04	.18	.4	.77	1.34	3.						
7½	.04	.14	.32	.59	.96	1.51	2.63					
8	.033	.13	.291	.54	.88	1.36	2.07	4.				
10	.025	.10	.23	.43	.56	1.00	1.43	2.	2.82	5.		
12	.020	.08	.19	.35	.54	.81	1.13	1.53	2.04	2.69	3.6	6.

How to Read the Table: Follow down the column headed "Diam. of Mill" until you come to the diameter of cutter which you are using. Follow across to the right until you come to the column under the **width** of cut which the cutter is taking. The figure given is the approach of the cutter.

Example: 10″ diameter face mill; 8″ width of cut; approach of cutter is 2″.

Approach of Cutter for Spiral Mills, Keyway Cutters, Saws, Etc.

Diam. of Mill	DEPTH OF CUT											
	1/16″	1/8″	3/16″	1/4″	3/8″	1/2″	3/4″	1″	1½″	2″	3″	4″
1¼	.272	.37	.44	.50	.57	.612						
1½	.299	.41	.49	.56	.65	.71	.75					
1¾	.32	.45	.54	.61	.72	.79	.87					
2	.35	.48	.58	.66	.78	87	.97	1.00				
2¼	.37	.52	.62	.71	.84	.93	1.06	1.12				
2½	.39	.54	.66	.75	.89	1.00	1.15	1.22				
2¾	.41	.57	.69	.79	.94	1.06	1.22	1.32				
3	.43	.60	.73	.83	.99	1.12	1.30	1.41	1.50			
3¼	.45	.63	.76	.87	1.04	1.17	1.37	1.50	1.62			
3½	.46	.65	.79	.91	1.08	1.22	1.44	1.58	1.73			
3¾	.48	.67	.82	.93	1.13	1.28	1.50	1.66	1.84			
4	.49	.70	.85	.97	1.17	1.32	1.56	1.73	1.94	2.00		
4¼	.51	.72	.87	1.00	1.21	1.37	1.62	1.80	2.03	2.12		
4½	.53	.74	.90	1.03	1.24	1.41	1.67	1.87	2.12	2.24		
4¾	.54	.76	.92	1.06	1.28	1.46	1.73	1.93	2.21	2.35		
5	.56	.78	.95	1.09	1.32	1.50	1.79	2.00	2.29	2.45		
5½	.58	.82	1.00	1.14	1.39	1.58	1.89	2.12	2.45	2.64		
6	.61	.86	1.04	1.20	1.45	1.66	1.98	2.24	2.60	2.83	3 00	
6½	.634	.89	1.09	1.25	1.51	1.73	2.08	2.35	2.74	3.00	3.24	
7	.658	.93	1.13	1.30	1.58	1.80	2.17	2.45	2.87	3.16	3.46	
7½	.68	.95	1.17	1.35	1.63	1.87	2.25	2.55	3.00	3.32	3.67	
8	.71	.99	1.21	1.39	1.69	1.94	2.33	2.65	3.12	3.46	3.87	4.00
8½	.73	1.03	1.25	1.44	1.74	2.00	2.41	2.74	3.24	3.61	4.06	4.24
9	.75	1.05	1.28	1.48	1.80	2.06	2.49	2.83	3.36	3.74	4.24	4.47
9½	.77	1.08	1.32	1.52	1.85	2.12	2.56	2.92	3.47	3.88	4.42	4.69
10	.79	1.11	1.35	1.56	1.90	2.18	2.63	3.00	3.57	4.00	4.58	4.90
10½	.81	1.14	1.39	1.60	1.95	2.24	2.71	3.08	3.67	4.12	4.75	5.10
11	.83	1.17	1 42	1.64	2.00	2.29	2.77	3.16	3.77	4.24	4.89	5.29
11½	.85	1.19	1.46	1.68	2.04	2.34	2.84	3.24	3.87	4.36	5.04	5.48
12	.86	1.22	1.49	1.72	2.09	2.40	2.91	3.32	3.97	4.47	5.19	5.65

How to Read the Table—Follow down the column headed "Diam. of Mill" until you come to the diameter of cutter which you are using. Follow across to the right until you come to the column under the **depth** of cut which the cutter is taking. The figure given is the approach of the cutter.

Example: 2¾″ diameter cutter, ¼″ depth of cut; approach of cutter is .79″.

MEMORANDUM

INDEX TABLES (Numerical Divisions)

For Standard Dividing Head Plate and Large Plate of Wide Range Divider

(See Pages 67 and 68 for method of calculating angular spacings and divisions not listed for the wide range divider)

Table of divisions obtainable with the standard Index Plate and the large plate of the Wide Range Divider, used with Dividing Heads, Gear Cutting Attachments, Spiral Milling Heads and Plain Centers.

The plates are drilled on both sides with circles of holes equally spaced. The number of holes in the circles are as follows:

Standard Dividing Head Plate	**First Side**—24-25-28-30-34-37-38-39-41-42-43 **Second Side**—46-47-49-51-53-54-57-58-59-62-66
Large Plate of Wide Range Divider	**First Side**—24-28-30-34-37-38-39-41-42-43-100 **Second Side**—46-47-49-51-53-54-57-58-59-62-66

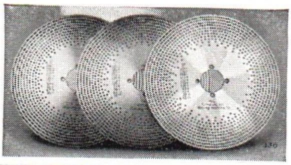
No. of Divisions	Circle	Turns	Spaces	No. of Divisions	Circle	Turns	Spaces	No. of Divisions	Circle	Spaces	No. of Divisions	Circle	Spaces	No. of Divisions	Circle	Spaces	No. of Divisions	Circle	Spaces
2	Any	20	....	**37**	37	1	3	**80**	24	12	**148**	37	10	**248**	62	10	**460**	46	4
3	24	13	8	**38**	38	1	2	**82**	41	20	**150**	30	8	**250**	25	4	**464**	58	5
4	Any	10	....	**39**	39	1	1	**84**	42	20	**152**	38	10	**255**	51	8	**470**	47	4
5	Any	8	....	**40**	Any	1	....	**85**	34	16	**155**	62	16	**260**	39	6	**472**	59	5
6	24	6	16	**41**	41	....	40	**86**	43	20	**156**	39	10	**264**	66	10	**480**	24	2
7	28	5	20	**42**	42	....	40	**88**	66	30	**160**	28	7	**270**	54	8	**490**	49	4
8	Any	5	....	**43**	43	....	40	**90**	54	24	**164**	41	10	**272**	34	5	**496**	62	5
9	54	4	24	**44**	66	....	60	**92**	46	20	**165**	66	16	**280**	28	4	**500**	25	2
10	Any	4	....	**45**	54	....	48	**94**	47	20	**168**	42	10	**290**	58	8	**510**	51	4
11	66	3	42	**46**	46	....	40	**95**	38	16	**170**	34	8	**296**	37	5	**520**	39	3
12	24	3	8	**47**	47	....	40	**96**	24	10	**172**	43	10	**300**	30	4	**528**	66	5
13	39	3	3	**48**	24	....	20	**98**	49	20	**176**	66	15	**304**	38	5	**530**	53	4
14	49	2	42	**49**	49	....	40	**100**	25	10	**180**	54	12	**310**	62	8	**540**	54	4
15	24	2	16	**50**	25	....	20	**102**	51	20	**184**	46	10	**312**	39	5	**560**	28	2
16	24	2	12	**51**	51	....	40	**104**	39	15	**185**	37	8	**320**	24	3	**570**	57	4
17	34	2	12	**52**	39	....	30	**105**	42	16	**188**	47	10	**328**	41	5	**580**	58	4
18	54	2	12	**53**	53	....	40	**106**	53	20	**190**	38	8	**330**	66	8	**590**	59	4
19	38	2	4	**54**	54	....	40	**108**	54	20	**192**	24	5	**336**	42	5	**600**	30	2
20	Any	2	....	**55**	66	....	48	**110**	66	24	**195**	39	8	**340**	34	4	**620**	62	4
21	42	1	38	**56**	28	....	20	**112**	28	10	**196**	49	10	**344**	43	5	**660**	66	4
22	66	1	54	**57**	57	....	40	**114**	57	20	**200**	30	6	**360**	54	6	**680**	34	2
23	46	1	34	**58**	58	....	40	**115**	46	16	**204**	51	10	**368**	46	5	**720**	54	3
24	24	1	16	**59**	59	....	40	**116**	58	20	**205**	41	8	**370**	37	4	**740**	37	2
25	25	1	15	**60**	24	....	16	**118**	59	20	**210**	42	8	**376**	47	5	**760**	38	2
26	39	1	21	**62**	62	....	40	**120**	24	8	**212**	53	10	**380**	38	4	**780**	39	2
27	54	1	26	**64**	24	....	15	**124**	62	20	**215**	43	8	**390**	39	4	**820**	41	2
28	42	1	18	**65**	39	....	24	**125**	25	8	**216**	54	10	**392**	49	5	**840**	42	2
29	58	1	22	**66**	66	....	40	**130**	39	12	**220**	66	12	**400**	30	3	**860**	43	2
30	24	1	8	**68**	34	....	20	**132**	66	20	**224**	28	5	**408**	51	5	**880**	66	3
31	62	1	18	**70**	28	....	16	**135**	54	16	**228**	57	10	**410**	41	4	**920**	46	2
32	28	1	7	**72**	54	....	30	**136**	34	10	**230**	46	8	**420**	42	4	**940**	47	2
33	66	1	14	**74**	37	....	20	**140**	28	8	**232**	58	10	**424**	53	5	**960**	24	1
34	34	1	6	**75**	30	....	16	**144**	54	15	**235**	47	8	**430**	43	4	**980**	49	2
35	28	1	4	**76**	38	....	20	**145**	58	16	**236**	59	10	**432**	54	5	**1000**	25	1
36	54	1	6	**78**	39	....	20				**240**	24	4	**440**	66	6			
											245	49	8	**456**	57	5			

INDEX TABLE (Numerical Divisions)

FOR HIGH NUMBER INDEXING ATTACHMENT

Indexes all numbers up to and including 200; all even numbers and those divisible by 5 up to and including 400, except 225, 275, 325, 375.
This attachment consists of a set of 3 index plates which are drilled on six sides, A, B, C, D, E and F.
Example to index 35 divisions—This division can be made from side F, D, A or E. The preferred side is F, since this requires the least number of holes. But should either D, A or E be in place, it can be used, thus avoiding the bother of changing plates.

No. of Div.	Side	Circle	Turns	Spaces	No. of Div.	Side	Circle	Turns	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces
2	Any	Any	20	....	**19**	F	38	2	4	**41**	C	123	120	**70**	D	42	24
3	A	30	13	10	**19**	E	133	2	14	**42**	E	42	40	**70**	A	91	52
3	B	36	13	12	**19**	A	171	2	18	**42**	A	147	140	**70**	E	119	68
3	E	42	13	14	**20**	Any	Any	2	....	**43**	A	129	120	**71**	F	71	40
3	C	93	13	31	**21**	E	42	1	38	**44**	D	44	40	**72**	B	36	20
3	F	159	13	53	**21**	A	147	1	133	**44**	A	99	90	**72**	A	117	65
4	Any	Any	10	....	**22**	D	44	1	36	**44**	F	143	130	**72**	C	153	85
5	Any	Any	8	....	**22**	A	99	1	81	**45**	B	36	32	**73**	E	73	40
6	A	30	6	20	**22**	F	143	1	117	**45**	A	99	88	**74**	B	111	60
6	B	36	6	24	**23**	C	46	1	34	**45**	C	153	136	**75**	A	30	16
6	E	42	6	28	**23**	A	69	1	51	**46**	C	46	40	**76**	F	38	20
6	C	93	6	62	**23**	E	161	1	119	**46**	A	69	60	**76**	E	133	70
6	F	159	6	106	**24**	A	30	1	20	**46**	E	161	140	**76**	A	171	90
7	F	28	5	20	**24**	B	36	1	24	**47**	B	141	120	**77**	D	77	40
7	E	42	5	30	**24**	E	42	1	28	**48**	A	30	25	**78**	A	117	60
7	D	77	5	55	**24**	C	93	1	62	**48**	B	36	30	**79**	C	79	40
7	A	91	5	65	**24**	F	159	1	106	**49**	A	147	120	**80**	E	26	13
8	Any	Any	5	....	**25**	A	30	1	18	**50**	A	30	24	**80**	F	28	14
9	B	36	4	16	**25**	E	175	1	105	**50**	E	175	140	**80**	A	30	15
9	A	99	4	44	**26**	E	26	1	14	**51**	C	153	120	**80**	D	32	16
9	C	153	4	68	**26**	A	91	1	49	**52**	E	26	20	**80**	C	34	17
10	Any	Any	4	....	**26**	B	169	1	91	**52**	A	91	70	**80**	B	36	18
11	D	44	3	28	**27**	B	81	1	39	**52**	F	143	110	**80**	E	42	21
11	A	99	3	63	**27**	A	189	1	91	**52**	B	169	130	**81**	B	81	40
11	F	143	3	91	**28**	F	28	1	12	**53**	F	159	120	**82**	C	123	60
12	A	30	3	10	**28**	E	42	1	18	**54**	B	81	60	**83**	F	83	40
12	B	36	3	12	**28**	D	77	1	33	**54**	A	189	140	**84**	E	42	20
12	E	42	3	14	**28**	A	91	1	39	**55**	D	44	32	**84**	A	147	70
12	C	93	3	31	**29**	E	87	1	33	**55**	F	143	104	**85**	C	34	16
12	F	159	3	53	**30**	A	30	1	10	**56**	F	28	20	**85**	E	119	56
13	E	26	3	2	**30**	B	36	1	12	**56**	E	42	30	**85**	F	187	88
13	A	91	3	7	**30**	E	42	1	14	**56**	D	77	55	**86**	A	129	60
13	F	143	3	11	**30**	C	93	1	31	**56**	A	91	65	**87**	E	87	40
13	B	169	3	13	**30**	F	159	1	53	**57**	A	171	120	**88**	D	44	20
14	F	28	2	24	**31**	C	93	1	27	**58**	E	87	60	**88**	A	99	45
14	E	42	2	36	**32**	F	28	1	7	**59**	A	177	120	**88**	F	143	65
14	D	77	2	66	**32**	D	32	1	8	**60**	A	30	20	**89**	D	89	40
14	A	91	2	78	**32**	B	36	1	9	**60**	B	36	24	**90**	B	36	16
15	A	30	2	20	**32**	A	48	1	12	**60**	E	42	28	**90**	A	99	44
15	B	36	2	24	**33**	A	99	1	21	**60**	F	159	106	**90**	C	153	68
15	E	42	2	28	**34**	C	34	1	6	**61**	B	183	120	**91**	A	91	40
15	C	93	2	62	**34**	E	119	1	21	**62**	C	93	60	**92**	C	46	20
15	F	159	2	106	**34**	F	187	1	33	**63**	A	189	120	**92**	A	69	30
16	E	26	2	13	**35**	F	28	1	4	**64**	D	32	20	**92**	E	161	70
16	F	28	2	14	**35**	D	77	1	11	**64**	A	48	30	**93**	C	93	40
16	A	30	2	15	**35**	A	91	1	13	**65**	E	26	16	**94**	B	141	60
16	D	32	2	16	**35**	E	119	1	17	**65**	A	91	56	**95**	F	38	16
16	C	34	2	17	**36**	B	36	1	4	**65**	F	143	88	**95**	E	133	56
16	B	36	2	18	**36**	A	99	1	11	**65**	B	169	104	**95**	A	171	72
17	C	34	2	12	**36**	C	153	1	17	**66**	A	99	60	**96**	B	36	15
17	E	119	2	42	**37**	B	111	1	9	**67**	B	67	40	**96**	A	48	20
17	C	153	2	54	**38**	F	38	1	2	**68**	C	34	20	**97**	B	97	40
17	F	187	2	66	**38**	E	133	1	7	**68**	E	119	70	**98**	A	147	60
18	B	36	2	8	**38**	A	171	1	9	**68**	F	187	110	**99**	A	99	40
18	A	99	2	22	**39**	A	117	1	3	**69**	A	69	40	**100**	A	30	12
18	C	153	2	34	**40**	Any	Any	1	....	**70**	F	28	16	**100**	E	175	70



INDEX TABLE—(Concluded)

FOR HIGH NUMBER INDEXING ATTACHMENT

Fig. 107 . . The High Number Indexing Attachment is used by replacing the standard index plate with the High Number plate which will give you the number of divisions required.

No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces	No. of Div.	Side	Circle	Spaces
101	F	101	40	**137**	D	137	40	**180**	C	153	34	**240**	E	42	7	**320**	A	48	6
102	C	153	60	**138**	A	69	20	**181**	C	181	40	**240**	A	48	8	**322**	E	161	20
103	E	103	40	**139**	C	139	40	**182**	A	91	20	**242**	D	121	20	**324**	B	81	10
104	E	26	10	**140**	F	28	8	**183**	B	183	40	**244**	B	183	30	**326**	D	163	20
104	A	91	35	**140**	E	42	12	**184**	C	46	10	**245**	A	147	24	**328**	C	123	15
104	F	143	55	**140**	D	77	22	**184**	A	69	15	**246**	C	123	20	**330**	A	99	12
104	B	169	65	**140**	A	91	26	**184**	E	161	35	**248**	C	93	15	**332**	F	83	10
105	E	42	16	**141**	B	141	40	**185**	B	111	24	**250**	E	175	28	**334**	C	167	20
105	A	147	56	**142**	F	71	20	**186**	C	93	20	**252**	A	189	30	**335**	B	67	8
106	F	159	60	**143**	F	143	40	**187**	F	187	40	**254**	B	127	20	**336**	E	42	5
107	D	107	40	**144**	B	36	10	**188**	B	141	30	**255**	C	153	24	**338**	B	169	20
108	B	81	30	**145**	E	87	24	**189**	A	189	40	**256**	D	32	5	**340**	C	34	4
108	A	189	70	**146**	E	73	20	**190**	F	38	8	**258**	A	129	20	**340**	E	119	14
109	C	109	40	**147**	A	147	40	**190**	E	133	28	**260**	E	26	4	**340**	F	187	22
110	D	44	16	**148**	B	111	30	**190**	A	171	36	**260**	A	91	14	**342**	A	171	20
110	A	99	36	**149**	E	149	40	**191**	E	191	40	**260**	F	143	22	**344**	A	129	15
100	F	143	52	**150**	A	30	8	**192**	A	48	10	**260**	B	169	26	**345**	A	69	8
111	B	111	40	**151**	D	151	40	**193**	D	193	40	**262**	F	131	20	**346**	F	173	20
112	F	28	10	**152**	F	38	10	**194**	B	97	20	**264**	A	99	15	**348**	E	87	10
112	E	42	15	**152**	E	133	35	**195**	A	117	24	**265**	F	159	24	**350**	E	175	20
113	F	113	40	**152**	A	171	45	**196**	A	147	30	**266**	E	133	20	**352**	D	44	5
114	A	171	60	**153**	C	153	40	**197**	C	197	40	**268**	B	67	10	**354**	A	177	20
115	C	46	16	**154**	D	77	20	**198**	A	99	20	**270**	B	81	12	**355**	F	71	8
115	A	69	24	**155**	C	93	24	**199**	B	199	40	**270**	A	189	28	**356**	D	89	10
115	E	161	56	**156**	A	117	30	**200**	A	30	6	**272**	C	34	5	**358**	D	179	20
116	E	87	30	**157**	B	157	40	**200**	E	175	35	**274**	D	137	20	**360**	B	36	4
117	A	117	40	**158**	C	79	20	**202**	F	101	20	**276**	A	69	10	**360**	A	99	11
118	A	177	60	**159**	F	159	40	**204**	C	153	30	**278**	C	139	20	**360**	C	153	17
119	E	119	40	**160**	F	28	7	**205**	C	123	24	**280**	F	28	4	**362**	C	181	20
120	A	30	10	**160**	D	32	8	**206**	E	103	20	**280**	E	42	6	**364**	A	91	10
120	B	36	12	**160**	B	36	9	**208**	E	26	5	**280**	D	77	11	**365**	E	73	8
120	E	42	14	**160**	A	48	12	**210**	E	42	8	**280**	A	91	13	**366**	B	183	20
120	C	93	31	**161**	E	161	40	**210**	A	147	28	**282**	B	141	20	**368**	C	46	5
120	F	159	53	**162**	B	81	20	**212**	F	159	30	**284**	F	71	10	**370**	B	111	12
121	D	121	40	**163**	D	163	40	**214**	D	107	20	**285**	A	171	24	**372**	C	93	10
122	B	183	60	**164**	C	123	30	**215**	A	129	24	**286**	F	143	20	**374**	F	187	20
123	C	123	40	**165**	A	99	24	**216**	B	81	15	**288**	B	36	5	**376**	B	141	15
124	C	93	30	**166**	F	83	20	**216**	A	189	35	**290**	E	87	12	**378**	A	189	20
125	E	175	56	**167**	C	167	40	**218**	C	109	20	**292**	E	73	10	**380**	F	38	4
126	A	189	60	**168**	E	42	10	**220**	D	44	8	**294**	A	147	20	**380**	E	133	14
127	B	127	40	**168**	A	147	35	**220**	A	99	18	**295**	A	177	24	**380**	A	171	18
128	D	32	10	**169**	B	169	40	**220**	F	143	26	**296**	B	111	15	**382**	E	191	20
128	A	48	15	**170**	C	34	8	**222**	B	111	20	**298**	E	149	20	**384**	A	48	5
129	A	129	40	**170**	E	119	28	**224**	F	28	5	**300**	A	30	4	**385**	D	77	8
130	E	26	8	**170**	F	187	44	**226**	F	113	20	**302**	D	151	20	**386**	D	193	20
130	A	91	28	**171**	A	171	40	**228**	A	171	30	**304**	F	38	5	**388**	B	97	10
130	F	143	44	**172**	A	129	30	**230**	C	46	8	**305**	B	183	24	**390**	A	117	12
130	B	169	52	**173**	F	173	40	**230**	A	69	12	**306**	C	153	20	**392**	A	147	15
131	F	131	40	**174**	E	87	20	**230**	E	161	28	**308**	D	77	10	**394**	C	197	20
132	A	99	30	**175**	E	175	40	**232**	E	87	15	**310**	C	93	12	**395**	C	79	8
133	E	133	40	**176**	D	44	10	**234**	A	117	20	**312**	A	117	15	**396**	A	99	10
134	B	67	20	**177**	A	177	40	**235**	B	141	24	**314**	B	157	20	**398**	B	199	20
135	B	81	24	**178**	D	89	20	**236**	A	177	30	**315**	A	189	24	**400**	A	30	3
135	A	189	56	**179**	D	179	40	**238**	E	119	20	**316**	C	79	10	....	....	....	....
136	C	34	10	**180**	B	36	8	**240**	A	30	5	**318**	F	159	20	....	....	....	....
136	E	119	35	**180**	A	99	22	**240**	B	36	6	**320**	D	32	4	....	....	....	....

TABLE OF ANGULAR DIVISIONS
Obtainable With Standard Dividing Head and Wide Range Divider

(Use 54-hole circle on large plate)

DEGREES

Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B	Degrees	Turns of Crank B	Spaces Crank B
1	....	6	41	4	30	81	9	....	121	13	24	161	17	48	201	22	18	241	26	42	281	31	12	321	35	36
2	....	12	42	4	36	82	9	6	122	13	30	162	18	....	202	22	24	242	26	48	282	31	18	322	35	42
3	....	18	43	4	42	83	9	12	123	13	36	163	18	6	203	22	30	243	27	....	283	31	24	323	35	48
4	....	24	44	4	48	84	9	18	124	13	42	164	18	12	204	22	36	244	27	6	284	31	30	324	36	....
5	....	30	45	5	....	85	9	24	125	13	48	165	18	18	205	22	42	245	27	12	285	31	36	325	36	6
6	....	36	46	5	6	86	9	30	126	14	....	166	18	24	206	22	48	246	27	18	286	31	42	326	36	12
7	....	42	47	5	12	87	9	36	127	14	6	167	18	30	207	23	....	247	27	24	287	31	48	327	36	18
8	....	48	48	5	18	88	9	42	128	14	12	168	18	36	208	23	6	248	27	30	288	32	....	328	36	24
9	1	....	49	5	24	89	9	48	129	14	18	169	18	42	209	23	12	249	27	36	289	32	6	329	36	30
10	1	6	50	5	30	90	10	....	130	14	24	170	18	48	210	23	18	250	27	42	290	32	12	330	36	36
11	1	12	51	5	36	91	10	6	131	14	30	171	19	....	211	23	24	251	27	48	291	32	18	331	36	42
12	1	18	52	5	42	92	10	12	132	14	36	172	19	6	212	23	30	252	28	....	292	32	24	332	36	48
13	1	24	53	5	48	93	10	18	133	14	42	173	19	12	213	23	36	253	28	6	293	32	30	333	37	....
14	1	30	54	6	....	94	10	24	134	14	48	174	19	18	214	23	42	254	28	12	294	32	36	334	37	6
15	1	36	55	6	6	95	10	30	135	15	....	175	19	24	215	23	48	255	28	18	295	32	42	335	37	12
16	1	42	56	6	12	96	10	36	136	15	6	176	19	30	216	24	....	256	28	24	296	32	48	336	37	18
17	1	48	57	6	18	97	10	42	137	15	12	177	19	36	217	24	6	257	28	30	297	33	....	337	37	24
18	2	....	58	6	24	98	10	48	138	15	18	178	19	42	218	24	12	258	28	36	298	33	6	338	37	30
19	2	6	59	6	30	99	11	....	139	15	24	179	19	48	219	24	18	259	28	42	299	33	12	339	37	36
20	2	12	60	6	36	100	11	6	140	15	30	180	20	....	220	24	24	260	28	48	300	33	18	340	37	42
21	2	18	61	6	42	101	11	12	141	15	36	181	20	6	221	24	30	261	29	....	301	33	24	341	37	48
22	2	24	62	6	48	102	11	18	142	15	42	182	20	12	222	24	36	262	29	6	302	33	30	342	38	....
23	2	30	63	7	....	103	11	24	143	15	48	183	20	18	223	24	42	263	29	12	303	33	36	343	38	6
24	2	36	64	7	6	104	11	30	144	16	....	184	20	24	224	24	48	264	29	18	304	33	42	344	38	12
25	2	42	65	7	12	105	11	36	145	16	6	185	20	30	225	25	....	265	29	24	305	33	48	345	38	18
26	2	48	66	7	18	106	11	42	146	16	12	186	20	36	226	25	6	266	29	30	306	34	....	346	38	24
27	3	....	67	7	24	107	11	48	147	16	18	187	20	42	227	25	12	267	29	36	307	34	6	347	38	30
28	3	6	68	7	30	108	12	....	148	16	24	188	20	48	228	25	18	268	29	42	308	34	12	348	38	36
29	3	12	69	7	36	109	12	6	149	16	30	189	21	....	229	25	24	269	29	48	309	34	18	349	38	42
30	3	18	70	7	42	110	12	12	150	16	36	190	21	6	230	25	30	270	30	....	310	34	24	350	38	48
31	3	24	71	7	48	111	12	18	151	16	42	191	21	12	231	25	36	271	30	6	311	34	30	351	39	....
32	3	30	72	8	....	112	12	24	152	16	48	192	21	18	232	25	42	272	30	12	312	34	36	352	39	6
33	3	36	73	8	6	113	12	30	153	17	....	193	21	24	233	25	48	273	30	18	313	34	42	353	39	12
34	3	42	74	8	12	114	12	36	154	17	6	194	21	30	234	26	....	274	30	24	314	34	48	354	39	18
35	3	48	75	8	18	115	12	42	155	17	12	195	21	36	235	26	6	275	30	30	315	35	....	355	39	24
36	4	....	76	8	24	116	12	48	156	17	18	196	21	42	236	26	12	276	30	36	316	35	6	356	39	30
37	4	6	77	8	30	117	13	....	157	17	24	197	21	48	237	26	18	277	30	42	317	35	12	357	39	36
38	4	12	78	8	36	118	13	6	158	17	30	198	22	....	238	26	24	278	30	48	318	35	18	358	39	42
39	4	18	79	8	42	119	13	12	159	17	36	199	22	6	239	26	30	279	31	....	319	35	24	359	39	48
40	4	24	80	8	48	120	13	18	160	17	42	200	22	12	240	26	36	280	31	6	320	35	30	360	40	....

TABLE OF ANGULAR DIVISIONS . . . Obtainable With Wide Range Divider

(Use 54-hole circle on small plate)

FRACTIONS OF A DEGREE

Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D	Minutes	Seconds	Turns of Crank D	Spaces Crank D
0	6	....	1	8	...	1	26	16	...	2	52	24	...	4	24	32	...	5	50	40	...	7	22	48	...	8	48	56	...	10	20
0	12	....	2	8	12	1	28	16	12	3	....	24	12	4	26	32	12	5	52	40	12	7	24	48	12	8	50	56	12	10	22
0	24	....	4	8	24	1	30	16	24	3	2	24	24	4	28	32	24	6	....	40	24	7	26	48	24	8	52	56	24	10	24
0	36	....	6	8	36	1	32	16	36	3	4	24	36	4	30	32	36	6	2	40	36	7	28	48	36	9	....	56	36	10	26
0	48	....	8	8	48	1	34	16	48	3	6	24	48	4	32	32	48	6	4	40	48	7	30	48	48	9	2	56	48	10	28
1	...	....	10	9	...	1	36	17	...	3	8	25	...	4	34	33	...	6	6	41	...	7	32	49	...	9	4	57	...	10	30
1	12	....	12	9	12	1	38	17	12	3	10	25	12	4	36	33	12	6	8	41	12	7	34	49	12	9	6	57	12	10	32
1	24	....	14	9	24	1	40	17	24	3	12	25	24	4	38	33	24	6	10	41	24	7	36	49	24	9	8	57	24	10	34
1	36	....	16	9	36	1	42	17	36	3	14	25	36	4	40	33	36	6	12	41	36	7	38	49	36	9	10	57	36	10	36
1	48	....	18	9	48	1	44	17	48	3	16	25	48	4	42	33	48	6	14	41	48	7	40	49	48	9	12	57	48	10	38
2	...	....	20	10	...	1	46	18	...	3	18	26	...	4	44	34	...	6	16	42	...	7	42	50	...	9	14	58	...	10	40
2	12	....	22	10	12	1	48	18	12	3	20	26	12	4	46	34	12	6	18	42	12	7	44	50	12	9	16	58	12	10	42
2	24	....	24	10	24	1	50	18	24	3	22	26	24	4	48	34	24	6	20	42	24	7	46	50	24	9	18	58	24	10	44
2	36	....	26	10	36	1	52	18	36	3	24	26	36	4	50	34	36	6	22	42	36	7	48	50	36	9	20	58	36	10	46
2	48	....	28	10	48	2	....	18	48	3	26	26	48	4	52	34	48	6	24	42	48	7	50	50	48	9	22	58	48	10	48
3	...	....	30	11	...	2	2	19	...	3	28	27	...	5	....	35	...	6	26	43	...	7	52	51	...	9	24	59	...	10	50
3	12	....	32	11	12	2	4	19	12	3	30	27	12	5	2	35	12	6	28	43	12	8	....	51	12	9	26	59	12	10	52
3	24	....	34	11	24	2	6	19	24	3	32	27	24	5	4	35	24	6	30	43	24	8	2	51	24	9	28	59	24	11	....
3	36	....	36	11	36	2	8	19	36	3	34	27	36	5	6	35	36	6	32	43	36	8	4	51	36	9	30	59	36	11	2
3	48	...	38	11	48	2	10	19	48	3	36	27	48	5	8	35	48	6	34	43	48	8	6	51	48	9	32	59	48	11	4
4	...	....	40	12	...	2	12	20	...	3	38	28	...	5	10	36	...	6	36	44	...	8	8	52	...	9	34	...	...	....	....
4	12	....	42	12	12	2	14	20	12	3	40	28	12	5	12	36	12	6	38	44	12	8	10	52	12	9	36	...	...	....	....
4	24	....	44	12	24	2	16	20	24	3	42	28	24	5	14	36	24	6	40	44	24	8	12	52	24	9	38	...	...	....	....
4	36	....	46	12	36	2	18	20	36	3	44	28	36	5	16	36	36	6	42	44	36	8	14	52	36	9	40	...	...	....	....
4	48	....	48	12	48	2	20	20	48	3	46	28	48	5	18	36	48	6	44	44	48	8	16	52	48	9	42	...	...	....	....
5	...	....	50	13	...	2	22	21	...	3	48	29	...	5	20	37	...	6	46	45	...	8	18	53	...	9	44	...	...	....	....
5	12	....	52	13	12	2	24	21	12	3	50	29	12	5	22	37	12	6	48	45	12	8	20	53	12	9	46	...	...	....	....
5	24	1	....	13	24	2	26	21	24	3	52	29	24	5	24	37	24	6	50	45	24	8	22	53	24	9	48	...	...	....	....
5	36	1	2	13	36	2	28	21	36	4	....	29	36	5	26	37	36	6	52	45	36	8	24	53	36	9	50	...	...	....	....
5	48	1	4	13	48	2	30	21	48	4	2	29	48	5	28	37	48	7	....	45	48	8	26	53	48	9	52	...	...	....	....
6	...	1	6	14	...	2	32	22	...	4	4	30	...	5	30	38	...	7	2	46	...	8	28	54	...	10	....	...	...	....	....
6	12	1	8	14	12	2	34	22	12	4	6	30	12	5	32	38	12	7	4	46	12	8	30	54	12	10	2	...	...	....	....
6	24	1	10	14	24	2	36	22	24	4	8	30	24	5	34	38	24	7	6	46	24	8	32	54	24	10	4	...	...	....	....
6	36	1	12	14	36	2	38	22	36	4	10	30	36	5	36	38	36	7	8	46	36	8	34	54	36	10	6	...	...	....	....
6	48	1	14	14	48	2	40	22	48	4	12	30	48	5	38	38	48	7	10	46	48	8	36	54	48	10	8	...	...	....	....
7	...	1	16	15	...	2	42	23	...	4	14	31	...	5	40	39	...	7	12	47	...	8	38	55	...	10	10	...	...	....	....
7	12	1	18	15	12	2	44	23	12	4	16	31	12	5	42	39	12	7	14	47	12	8	40	55	12	10	12	...	...	....	....
7	24	1	20	15	24	2	46	23	24	4	18	31	24	5	44	39	24	7	16	47	24	8	42	55	24	10	14	...	...	....	....
7	36	1	22	15	36	2	48	23	36	4	20	31	36	5	46	39	36	7	18	47	36	8	44	55	36	10	16	...	...	....	....
7	48	1	24	15	48	2	50	23	48	4	22	31	48	5	48	39	48	7	20	47	48	8	46	55	48	10	18	...	...	....	....

NOTE.—When indexing degrees and fractions of a degree. Cranks "B" and "D" in above tables indicated in Figure 66, are both moved in the same direction.

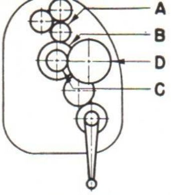


TABLE OF LEADS (2.500 to 3.800)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
2.500	27	45	20	48	**2.923**	19	39	27	45	**3.385**	22	39	27	45
2.507	22	39	20	45	**2.927**	19	51	33	42	**3.389**	22	42	33	51
2.510	24	45	24	51	**2.930**	20	39	24	42	**3.394**	21	33	24	45
2.513	19	36	20	42	**2.941**	24	51	30	48	**3.399**	39	45	20	51
2.516	21	36	22	51	**2.946**	22	42	27	48	**3.409**	27	33	20	48
2.521	20	42	27	51	**2.956**	21	30	19	45	**3.415**	33	36	19	51
2.530	17	42	30	48	**2.966**	22	51	33	48	**3.422**	24	33	24	51
2.534	21	39	24	51	**2.976**	20	48	30	42	**3.429**	24	42	27	45
2.540	20	42	24	45	**2.986**	22	39	27	51	**3.437**	27	36	22	48
2.546	22	36	20	48	**2.991**	20	36	21	39	**3.440**	22	27	19	45
2.552	22	39	19	42	**2.995**	21	33	24	51	**3.451**	24	30	22	51
2.561	19	51	33	48	**3.000**	21	55	33	42	**3.457**	21	27	20	45
2.567	24	33	18	51	**3.009**	22	45	24	39	**3.462**	27	39	24	48
2.574	21	48	30	51	**3.017**	20	51	30	39	**3.472**	30	36	20	48
2.579	19	39	27	51	**3.025**	24	42	27	51	**3.480**	30	39	19	42
2.588	22	51	27	45	**3.029**	21	39	27	48	**3.486**	24	27	20	51
2.593	21	36	20	45	**3.039**	18	55	39	42	**3.492**	30	42	22	45
2.598	24	39	19	45	**3.048**	24	42	24	45	**3.500**	36	45	21	48
2.608	21	30	19	51	**3.056**	22	45	30	48	**3.505**	39	48	22	51
2.614	20	51	30	45	**3.068**	27	33	18	48	**3.516**	24	39	24	42
2.619	22	42	24	48	**3.077**	20	39	27	45	**3.526**	30	39	22	48
2.625	21	45	27	48	**3.081**	22	51	30	42	**3.535**	21	33	20	36
2.632	21	39	22	45	**3.088**	21	51	36	48	**3.543**	24	33	19	39
2.639	19	45	30	48	**3.096**	22	30	19	45	**3.556**	24	36	24	45
2.647	24	48	27	51	**3.105**	30	36	19	51	**3.565**	30	33	20	51
2.655	22	39	24	51	**3.111**	24	36	21	45	**3.571**	30	42	24	48
2.661	19	51	30	42	**3.117**	24	33	18	42	**3.580**	27	33	21	48
2.667	24	45	24	48	**3.125**	21	42	30	48	**3.590**	42	39	17	51
2.674	21	36	22	48	**3.134**	20	36	22	39	**3.595**	30	36	22	51
2.679	20	42	27	48	**3.143**	22	42	27	45	**3.603**	21	48	42	51
2.689	24	42	24	51	**3.152**	19	51	33	39	**3.611**	39	36	17	51
2.696	22	51	30	48	**3.163**	22	45	33	51	**3.620**	30	39	24	51
2.707	20	36	19	39	**3.173**	27	39	22	48	**3.626**	27	39	22	42
2.715	20	39	27	51	**3.182**	24	33	21	48	**3.636**	24	33	24	48
2.727	21	33	18	42	**3.189**	19	55	36	39	**3.641**	39	42	20	51
2.735	24	39	20	45	**3.199**	20	33	19	36	**3.650**	33	39	22	51
2.745	24	36	21	51	**3.205**	20	39	30	48	**3.660**	24	27	21	51
2.750	22	45	27	48	**3.214**	24	48	27	42	**3.667**	24	30	22	48
2.764	19	55	36	45	**3.223**	22	39	24	42	**3.676**	39	42	19	48
2.773	22	42	27	51	**3.231**	27	39	21	45	**3.686**	22	27	19	42
2.778	20	45	30	48	**3.239**	27	33	19	48	**3.692**	27	39	24	45
2.784	24	39	19	42	**3.248**	19	45	30	39	**3.697**	33	42	24	51
2.794	22	42	24	45	**3.258**	27	39	24	51	**3.702**	33	39	21	48
2.801	20	42	30	51	**3.263**	21	33	20	39	**3.706**	27	30	21	51
2.812	21	42	27	48	**3.268**	30	36	20	51	**3.714**	39	42	18	45
2.820	22	39	24	48	**3.274**	22	48	30	42	**3.720**	19	55	42	39
2.824	24	51	27	45	**3.282**	24	39	24	45	**3.730**	24	33	20	39
2.831	21	51	33	48	**3.284**	21	27	19	45	**3.739**	22	51	39	45
2.842	19	36	21	39	**3.291**	21	39	22	36	**3.743**	30	33	21	51
2.851	21	39	27	51	**3.297**	20	39	27	42	**3.750**	18	45	..	48
2.857	24	42	24	48	**3.309**	27	48	30	51	**3.753**	24	27	19	45
2.866	19	39	30	51	**3.318**	22	51	30	39	**3.761**	30	39	22	45
2.876	22	51	30	45	**3.329**	17	55	42	39	**3.765**	24	30	24	51
2.879	24	33	19	48	**3.333**	21	42	30	45	**3.770**	30	36	19	42
2.885	20	39	27	48	**3.346**	21	51	39	48	**3.775**	33	36	21	51
2.896	24	39	24	51	**3.353**	27	30	19	51	**3.782**	30	42	27	51
2.903	19	45	33	48	**3.361**	22	45	33	48	**3.788**	30	33	20	48
2.910	20	36	22	42	**3.369**	27	33	21	51	**3.792**	39	45	21	48
2.917	21	45	30	48	**3.377**	20	55	39	42	**3.800**	27	30	19	45

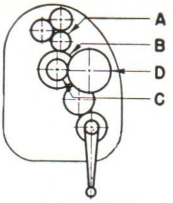


TABLE OF LEADS (3.810 to 5.025)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
3.810	30	42	24	45	**4.202**	45	42	20	51	**4.606**	36	33	19	45
3.818	27	33	21	45	**4.215**	17	55	45	33	**4.615**	18	42	..	39
3.824	39	42	21	51	**4.222**	19	42	..	45	**4.622**	33	42	30	51
3.828	33	39	19	42	**4.231**	33	39	24	48	**4.628**	20	55	42	33
3.834	24	27	22	51	**4.235**	27	30	24	51	**4.635**	39	33	20	51
3.838	30	33	19	45	**4.242**	30	33	21	45	**4.643**	39	42	24	48
3.843	21	51	42	45	**4.248**	39	36	20	51	**4.646**	42	39	22	51
3.850	27	33	24	51	**4.256**	39	42	22	48	**4.656**	24	27	22	42
3.860	21	51	45	48	**4.263**	42	39	19	48	**4.662**	30	33	20	39
3.869	39	42	20	48	**4.267**	24	30	24	45	**4.667**	21	39	..	45
3.878	33	39	22	48	**4.274**	30	36	20	39	**4.673**	39	36	22	51
3.882	27	30	22	51	**4.278**	33	36	21	45	**4.678**	39	33	19	48
3.889	30	36	21	45	**4.286**	18	45	..	42	**4.687**	30	36	27	48
3.897	36	39	19	45	**4.293**	30	33	17	36	**4.691**	30	27	19	45
3.911	24	30	22	45	**4.299**	45	39	19	51	**4.701**	30	36	22	39
3.916	24	33	21	39	**4.308**	36	39	21	45	**4.706**	24	36	..	51
3.922	20	48	..	51	**4.314**	22	45	..	51	**4.711**	19	55	45	33
3.929	33	42	24	48	**4.318**	36	33	19	48	**4.714**	33	42	27	45
3.937	27	30	21	48	**4.327**	30	39	27	48	**4.722**	17	42	..	36
3.949	33	39	21	45	**4.333**	39	45	24	48	**4.727**	39	33	18	45
3.954	33	36	22	51	**4.344**	36	39	24	51	**4.740**	39	36	21	48
3.958	19	45	..	48	**4.354**	33	30	19	48	**4.745**	33	30	22	51
3.963	30	33	17	39	**4.364**	27	33	24	45	**4.751**	21	51	45	39
3.968	30	36	20	42	**4.370**	24	42	39	51	**4.762**	20	39	..	42
3.972	39	45	22	48	**4.375**	21	45	..	48	**4.773**	36	33	21	48
3.977	30	33	21	48	**4.387**	22	27	21	39	**4.777**	17	55	51	33
3.982	33	39	24	51	**4.392**	24	45	42	51	**4.786**	42	39	20	45
3.986	27	33	19	39	**4.396**	30	39	24	42	**4.793**	30	27	22	51
3.992	45	42	19	51	**4.400**	27	30	22	45	**4.800**	27	30	24	45
4.000	27	36	24	45	**4.406**	27	33	21	39	**4.807**	19	48	51	42
4.006	39	42	22	51	**4.412**	30	36	27	51	**4.813**	30	33	27	51
4.011	33	36	21	48	**4.420**	33	42	27	48	**4.821**	36	42	27	48
4.018	30	42	27	48	**4.429**	30	33	19	39	**4.827**	48	39	20	51
4.021	24	27	19	42	**4.434**	42	39	21	51	**4.835**	33	39	24	42
4.029	30	39	22	42	**4.444**	20	42	..	45	**4.843**	39	30	19	51
4.034	36	42	24	51	**4.453**	27	24	19	48	**4.848**	30	33	24	45
4.040	30	33	20	45	**4.461**	39	36	21	51	**4.853**	33	36	27	51
4.048	17	39	..	42	**4.466**	33	36	19	39	**4.858**	27	22	19	48
4.060	30	36	19	39	**4.471**	36	30	19	51	**4.866**	39	33	21	51
4.064	36	33	19	51	**4.476**	24	33	24	39	**4.875**	39	30	18	48
4.072	30	39	27	51	**4.480**	33	39	27	51	**4.887**	36	39	27	51
4.078	24	45	39	51	**4.486**	19	48	51	45	**4.895**	30	33	21	39
4.083	21	48	42	45	**4.492**	36	33	21	51	**4.902**	45	36	20	51
4.091	27	33	21	42	**4.500**	27	30	24	48	**4.911**	33	42	30	48
4.098	33	30	19	51	**4.508**	42	33	17	48	**4.916**	27	42	39	51
4.103	30	39	24	45	**4.514**	39	36	20	48	**4.922**	27	24	21	48
4.113	30	33	19	42	**4.524**	19	45	..	42	**4.926**	42	36	19	45
4.118	21	48	..	51	**4.529**	33	30	21	51	**4.935**	36	33	19	42
4.125	33	45	27	48	**4.533**	36	30	17	45	**4.941**	36	30	21	51
4.136	21	55	39	36	**4.540**	39	42	22	45	**4.945**	30	39	27	42
4.147	33	36	19	42	**4.547**	42	39	19	45	**4.948**	45	36	19	48
4.156	24	33	24	42	**4.553**	33	27	19	51	**4.952**	39	42	24	45
4.160	33	42	27	51	**4.558**	24	27	20	39	**4.959**	20	55	45	33
4.167	20	39	..	48	**4.567**	45	39	19	48	**4.967**	48	36	19	51
4.171	39	33	18	51	**4.571**	36	42	24	45	**4.977**	33	39	30	51
4.176	36	39	19	42	**4.575**	42	36	20	51	**4.990**	39	33	19	45
4.183	20	51	48	45	**4.583**	22	39	..	48	**5.000**	24	36	..	48
4.190	33	42	24	45	**4.588**	39	30	18	51	**5.014**	24	27	22	39
4.196	27	33	20	39	**4.602**	27	22	18	48	**5.025**	19	55	48	33

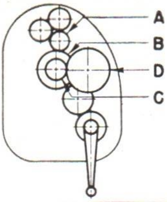


TABLE OF LEADS (5.033 to 6.291)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
5.033	42	36	22	51	5.440	33	39	27	42	5.882	30	36	..	51
5.038	42	33	19	48	5.444	42	36	21	45	5.887	48	33	17	42
5.042	33	30	22	48	5.455	36	33	24	48	5.893	33	36	27	42
5.048	45	39	21	48	5.469	45	36	21	48	5.903	55	33	17	48
5.056	39	36	21	45	5.481	27	24	19	39	5.911	42	30	19	45
5.065	39	33	18	42	5.489	39	30	19	45	5.921	30	19	18	48
5.068	21	51	48	39	5.495	45	39	20	42	5.926	24	27	24	36
5.077	33	39	27	45	5.500	33	36	27	45	5.934	36	39	27	42
5.080	45	33	19	51	5.510	27	21	18	42	5.939	42	33	21	45
5.085	42	36	17	39	5.515	39	33	21	45	5.948	39	27	21	51
5.091	36	33	21	45	5.527	19	55	48	30	5.954	33	27	19	39
5.098	39	36	24	51	5.538	36	39	27	45	5.961	48	30	19	51
5.104	42	36	21	48	5.546	33	21	18	51	5.966	45	33	21	48
5.114	30	33	27	48	5.552	27	22	19	42	5.975	33	27	22	45
5.123	33	24	19	51	5.556	20	39	..	36	5.983	42	36	20	39
5.128	20	42	..	39	5.561	39	33	24	51	5.989	42	33	24	51
5.135	20	51	55	42	5.568	42	33	21	48	5.994	51	39	22	48
5.143	36	42	27	45	5.573	30	19	18	51	6.000	27	39	..	45
5.147	45	36	21	51	5.581	39	33	17	36	6.010	42	33	17	36
5.152	17	45	..	33	5.587	22	45	48	42	6.019	39	27	20	48
5.156	33	36	27	48	5.594	30	33	24	39	6.027	27	42	45	48
5.160	33	27	19	45	5.600	36	30	21	45	6.032	48	36	19	42
5.170	39	33	21	48	5.608	39	30	22	51	6.039	42	30	22	51
5.176	51	39	19	48	5.615	45	33	21	51	6.044	33	39	30	42
5.185	42	36	20	45	5.625	27	36	..	48	6.050	36	21	18	51
5.192	36	39	27	48	5.630	48	36	19	45	6.054	39	24	19	51
5.195	30	33	24	42	5.641	22	42	..	39	6.058	27	24	21	39
5.200	39	30	18	45	5.647	36	30	24	51	6.061	20	42	..	33
5.208	45	36	20	48	5.657	42	33	20	45	6.067	39	30	21	45
5.216	42	30	19	51	5.664	39	27	20	51	6.071	45	30	17	42
5.223	27	48	39	42	5.675	39	36	22	42	6.090	45	36	19	39
5.229	48	36	20	51	5.682	45	33	20	48	6.095	24	45	48	42
5.238	22	45	..	42	5.687	39	30	21	48	6.100	42	27	20	51
5.241	42	33	21	51	5.692	55	36	19	51	6.107	27	20	19	42
5.250	27	30	21	36	5.698	30	27	20	39	6.111	22	42	..	36
5.255	17	55	51	30	5.704	42	36	22	45	6.118	39	30	24	51
5.260	27	22	18	42	5.714	24	39	..	42	6.125	52	30	21	48
5.265	42	39	22	45	5.718	39	27	19	48	6.130	33	19	18	51
5.272	33	27	22	51	5.727	27	22	21	45	6.136	36	33	27	48
5.278	19	42	..	36	5.735	39	24	18	51	6.141	48	33	19	45
5.288	33	39	30	48	5.744	42	39	24	45	6.154	24	42	..	39
5.294	27	36	..	51	5.752	33	27	24	51	6.162	33	21	20	51
5.303	42	33	20	48	5.758	19	42	..	33	6.169	45	33	19	42
5.312	51	36	18	48	5.762	33	30	22	42	6.176	36	24	21	51
5.322	30	21	19	51	5.769	36	39	30	48	6.182	51	33	18	45
5.333	24	39	..	45	5.775	36	33	27	51	6.190	39	36	24	42
5.339	19	55	51	33	5.782	30	21	17	42	6.198	51	36	21	48
5.347	42	36	22	48	5.789	33	19	17	51	6.205	33	30	22	39
5.353	39	30	21	51	5.795	51	33	18	48	6.209	45	27	19	51
5.359	33	30	19	39	5.804	30	42	39	48	6.222	42	36	24	45
5.369	27	22	21	48	5.807	21	51	55	39	6.231	39	27	22	51
5.378	33	30	22	45	5.816	27	21	19	42	6.237	39	33	19	36
5.385	21	42	..	39	5.820	30	27	22	42	6.250	30	36	..	48
5.392	45	36	22	51	5.824	33	30	27	51	6.257	39	33	27	51
5.398	45	33	19	48	5.833	21	39	..	36	6.268	30	27	22	39
5.413	30	27	19	39	5.844	30	33	27	42	6.275	48	33	22	51
5.419	48	33	19	51	5.854	33	21	19	51	6.282	42	36	21	39
5.429	36	30	19	42	5.864	30	27	19	36	6.286	33	21	18	45
5.432	30	27	22	45	5.874	36	33	21	39	6.291	21	51	55	36

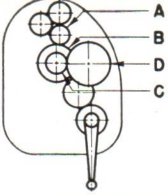


TABLE OF LEADS (6.296 to 7.483)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
6.296	17	45	..	27	**6.699**	33	24	19	39	**7.059**	45	30	24	51
6.303	39	33	24	45	**6.710**	42	27	22	51	**7.062**	39	27	22	45
6.316	36	19	17	51	**6.713**	36	33	24	39	**7.071**	33	30	27	44
6.319	39	27	21	48	**6.717**	42	33	19	36	**7.083**	17	45	..	22
6.333	19	42	..	30	**6.722**	33	24	22	45	**7.086**	48	33	19	39
6.340	48	33	17	39	**6.729**	51	30	19	48	**7.091**	39	33	27	45
6.346	33	36	27	39	**6.734**	30	27	20	33	**7.105**	36	29	18	48
6.349	48	36	20	42	**6.738**	42	33	27	51	**7.112**	42	22	19	51
6.353	36	30	27	51	**6.741**	39	27	21	45	**7.125**	36	20	19	48
6.356	39	30	22	45	**6.746**	55	33	17	42	**7.130**	42	27	22	48
6.364	21	42	..	33	**6.750**	36	30	27	48	**7.136**	51	27	17	45
6.375	51	30	18	48	**6.756**	48	30	19	45	**7.143**	30	39	..	42
6.387	36	21	19	51	**6.761**	51	33	21	48	**7.152**	33	19	21	51
6.393	22	45	51	39	**6.769**	33	30	24	39	**7.159**	42	33	27	48
6.400	36	30	24	45	**6.774**	60	33	19	51	**7.175**	39	22	17	42
6.405	42	27	21	51	**6.779**	33	21	22	51	**7.179**	42	36	24	39
6.410	45	36	20	39	**6.786**	45	30	19	42	**7.190**	33	27	30	51
6.417	36	33	30	51	**6.790**	30	27	22	36	**7.200**	36	30	27	45
6.420	39	27	20	45	**6.797**	39	27	24	51	**7.206**	42	24	21	51
6.429	27	39	..	42	**6.806**	42	27	21	48	**7.212**	51	33	21	45
6.439	45	33	17	36	**6.810**	39	30	22	42	**7.222**	39	27	24	48
6.447	22	42	48	39	**6.818**	36	33	30	48	**7.232**	33	17	19	51
6.451	33	27	19	36	**6.821**	42	30	19	39	**7.240**	30	39	48	51
6.462	42	39	27	45	**6.830**	55	30	19	51	**7.245**	39	19	18	51
6.465	48	33	20	45	**6.838**	48	36	20	39	**7.253**	36	39	33	42
6.471	33	36	..	51	**6.845**	24	51	48	33	**7.259**	42	27	21	45
6.477	36	22	19	48	**6.853**	42	33	21	39	**7.265**	45	27	17	39
6.481	42	27	20	48	**6.857**	36	30	24	42	**7.273**	24	42	..	33
6.490	27	39	45	48	**6.863**	45	27	21	51	**7.279**	33	24	27	51
6.494	45	33	20	42	**6.869**	48	33	17	36	**7.283**	39	21	20	51
6.500	39	30	24	48	**6.875**	33	30	..	48	**7.286**	51	30	18	42
6.513	33	19	18	48	**6.878**	39	27	20	42	**7.292**	45	27	21	48
6.519	33	27	24	45	**6.882**	39	30	27	51	**7.299**	39	22	21	51
6.525	51	33	19	45	**6.894**	39	33	21	36	**7.308**	45	30	19	39
6.531	33	20	19	48	**6.902**	48	30	22	51	**7.313**	39	20	18	48
6.536	45	27	20	51	**6.908**	30	19	21	48	**7.320**	42	27	24	51
6.545	36	33	27	45	**6.914**	42	27	20	45	**7.326**	30	21	20	39
6.555	39	21	18	51	**6.919**	39	21	19	51	**7.333**	33	36	..	45
6.563	36	24	21	48	**6.923**	27	42	..	39	**7.341**	19	55	51	24
6.568	42	27	19	45	**6.926**	48	33	20	42	**7.347**	27	21	24	42
6.577	39	21	17	48	**6.933**	39	30	24	45	**7.353**	45	24	20	51
6.581	42	36	22	39	**6.939**	36	21	17	42	**7.368**	30	19	21	45
6.588	42	30	24	51	**6.944**	45	27	20	48	**7.385**	36	30	24	39
6.593	45	39	24	42	**6.947**	33	19	18	45	**7.389**	42	24	19	45
6.600	33	30	27	45	**6.952**	39	33	30	51	**7.395**	33	21	24	51
6.608	27	22	21	39	**6.955**	18	55	51	24	**7.403**	36	22	19	42
6.611	42	24	17	45	**6.960**	30	21	19	39	**7.407**	20	45	..	27
6.618	30	24	27	51	**6.964**	39	36	27	42	**7.412**	42	30	27	51
6.623	51	33	18	42	**6.968**	33	39	42	51	**7.418**	45	39	27	42
6.632	27	19	21	45	**6.972**	48	27	20	51	**7.424**	42	33	21	36
6.635	33	21	19	45	**6.984**	48	36	22	42	**7.429**	39	30	24	42
6.643	45	33	19	39	**6.993**	45	33	20	39	**7.438**	51	30	21	48
6.648	39	33	27	48	**7.000**	21	42	..	30	**7.444**	33	19	18	42
6.667	30	36	..	45	**7.010**	39	24	22	51	**7.451**	42	21	19	51
6.679	33	20	17	42	**7.013**	36	33	27	42	**7.459**	48	33	20	39
6.684	55	36	21	48	**7.018**	30	19	20	45	**7.464**	33	20	19	42
6.687	36	19	18	51	**7.030**	33	19	17	42	**7.469**	33	27	22	36
6.691	39	24	21	51	**7.037**	19	45	..	27	**7.474**	36	17	18	51
6.696	30	42	45	48	**7.051**	30	24	22	39	**7.483**	30	21	22	42

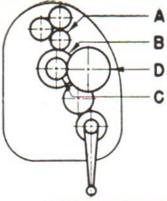


TABLE OF LEADS (7.487 to 8.766)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
7.487	42	33	30	51	7.889	36	17	19	51	8.319	33	21	27	51
7.492	33	19	22	51	7.897	42	30	22	39	8.322	51	33	21	39
7.500	36	33	..	48	7.901	48	27	20	45	8.333	30	39	..	36
7.506	48	27	19	45	7.908	33	18	22	51	8.342	39	22	24	51
7.517	39	21	17	42	7.912	48	39	27	42	8.352	42	22	21	48
7.521	48	36	22	39	7.917	19	42	..	24	8.357	39	30	27	42
7.529	51	33	19	39	7.933	51	30	21	45	8.366	48	27	24	51
7.538	42	30	21	39	7.944	39	36	33	45	8.374	33	17	22	51
7.549	42	24	22	51	7.955	42	33	30	48	8.381	48	30	22	42
7.552	36	33	27	39	7.964	33	39	48	51	8.388	55	27	21	51
7.557	42	22	19	48	7.972	36	22	19	39	8.392	36	33	30	39
7.563	33	20	22	48	7.977	42	27	20	39	8.400	42	30	27	45
7.566	39	27	22	42	7.983	45	21	19	51	8.403	45	21	20	51
7.571	33	19	17	39	7.988	55	27	20	51	8.412	39	30	33	51
7.576	60	33	20	48	7.993	33	17	21	51	8.422	45	22	21	51
7.583	39	30	21	36	8.000	36	33	..	45	8.426	39	27	21	36
7.589	55	27	19	51	8.011	39	21	22	51	8.438	36	24	27	48
7.597	39	33	27	42	8.016	33	19	18	39	8.444	48	24	19	45
7.600	36	20	19	45	8.021	42	24	22	48	8.452	39	19	21	51
7.605	42	27	22	45	8.028	51	24	17	45	8.462	33	36	..	39
7.612	33	17	20	51	8.036	45	36	27	42	8.471	36	17	18	45
7.615	33	30	27	39	8.042	48	27	19	42	8.482	45	24	19	42
7.619	48	30	20	42	8.050	39	19	20	51	8.488	55	27	20	48
7.623	39	27	19	36	8.059	30	21	22	39	8.493	33	17	21	48
7.628	42	24	17	39	8.063	55	27	19	48	8.497	39	27	30	51
7.636	36	22	21	45	8.067	36	21	24	51	8.502	30	19	21	39
7.639	33	27	30	48	8.072	39	18	19	51	8.512	39	24	22	42
7.646	51	27	17	42	8.077	45	30	21	39	8.515	48	21	19	51
7.656	42	24	21	48	8.081	60	33	20	45	8.523	45	22	20	48
7.669	48	27	22	51	8.088	33	24	30	51	8.531	39	20	21	48
7.677	36	27	19	33	8.095	17	45	..	21	8.538	55	24	19	51
7.684	33	17	19	48	8.105	33	19	21	45	8.545	51	27	19	42
7.692	30	36	..	39	8.114	21	55	51	24	8.553	39	19	20	48
7.697	39	19	18	48	8.120	55	33	19	39	8.556	42	30	22	36
7.700	33	20	21	45	8.128	48	22	19	51	8.571	36	33	..	42
7.704	39	27	24	45	8.143	36	20	19	42	8.576	39	24	19	36
7.714	36	30	27	42	8.148	22	42	..	27	8.594	33	24	30	48
7.721	45	24	21	51	8.157	51	33	19	36	8.603	39	24	27	51
7.727	17	45	..	22	8.163	30	21	24	42	8.615	42	30	24	39
7.734	33	24	27	48	8.167	42	24	21	45	8.627	42	21	22	51
7.738	39	36	30	42	8.173	45	24	17	39	8.636	19	45	..	22
7.741	55	30	19	45	8.182	27	39	..	33	8.643	33	20	22	42
7.749	48	27	17	39	8.196	33	17	19	45	8.654	45	36	27	39
7.758	48	33	24	45	8.205	48	36	24	39	8.661	48	27	19	39
7.765	36	30	33	51	8.211	39	19	18	45	8.667	39	33	..	45
7.778	21	42	..	27	8.231	33	21	22	42	8.673	45	21	17	42
7.792	51	30	22	48	8.235	48	24	21	51	8.684	33	19	24	48
7.800	39	30	27	45	8.242	51	33	24	35	8.693	51	22	18	48
7.813	45	24	20	48	8.250	33	20	24	48	8.708	33	20	19	36
7.822	48	30	22	45	8.254	39	27	24	42	8.715	60	27	20	51
7.829	42	19	17	48	8.259	36	19	17	39	8.720	36	17	21	51
7.832	42	33	24	39	8.264	51	27	21	48	8.727	36	30	24	33
7.841	39	21	19	45	8.273	39	30	21	33	8.730	33	27	30	42
7.846	51	30	18	39	8.282	51	30	19	39	8.739	39	21	24	51
7.857	33	36	..	42	8.289	36	19	21	48	8.745	27	19	24	39
7.861	42	22	21	51	8.296	42	27	24	45	8.750	21	45	..	24
7.870	45	27	17	36	8.305	36	17	20	51	8.754	39	27	20	33
7.875	42	30	27	48	8.308	36	30	27	39	8.758	51	22	17	45
7.879	39	33	30	45	8.312	48	33	24	42	8.766	45	33	27	42

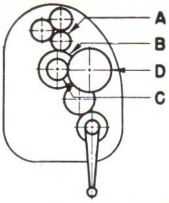


TABLE OF LEADS (8.769 to 10.094)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
8.769	36	20	19	39	**9.184**	30	21	27	42	**9.630**	39	27	24	36
8.775	42	27	22	39	**9.192**	39	27	21	33	**9.636**	42	19	17	39
8.782	33	17	19	42	**9.202**	51	27	19	39	**9.643**	36	24	27	42
8.787	55	27	22	51	**9.205**	36	22	27	48	**9.651**	48	21	19	45
8.791	30	21	24	39	**9.211**	42	19	20	48	**9.659**	39	19	24	51
8.796	60	27	19	48	**9.215**	55	27	19	42	**9.670**	33	21	24	39
8.800	33	20	24	45	**9.231**	36	33	..	39	**9.676**	55	24	19	45
8.811	42	33	27	39	**9.236**	42	24	19	36	**9.686**	39	17	19	45
8.815	51	27	21	45	**9.244**	45	21	22	51	**9.692**	42	30	27	39
8.821	39	20	19	42	**9.253**	45	22	19	42	**9.700**	55	27	20	42
8.827	39	27	22	36	**9.259**	60	27	20	48	**9.706**	36	24	33	51
8.831	48	22	17	42	**9.273**	51	33	27	45	**9.714**	51	21	18	45
8.839	33	24	27	42	**9.281**	33	20	27	48	**9.722**	45	27	21	36
8.844	39	21	20	42	**9.288**	45	19	20	51	**9.728**	39	21	22	42
8.854	55	22	17	48	**9.297**	51	24	21	48	**9.740**	45	33	30	42
8.864	39	33	36	48	**9.301**	42	22	19	39	**9.744**	48	24	19	39
8.867	42	20	19	45	**9.308**	33	20	22	39	**9.750**	39	30	27	36
8.882	45	19	18	48	**9.314**	60	24	19	51	**9.757**	55	21	19	51
8.889	24	42	..	27	**9.333**	42	30	24	36	**9.770**	33	19	27	48
8.897	33	17	22	48	**9.341**	45	21	17	39	**9.778**	55	30	24	45
8.905	51	30	22	42	**9.346**	39	27	33	51	**9.788**	51	30	19	33
8.909	42	22	21	45	**9.351**	48	33	27	42	**9.796**	36	21	24	42
8.916	36	19	24	51	**9.356**	39	24	19	33	**9.800**	42	20	21	45
8.922	39	18	21	51	**9.375**	36	24	30	48	**9.808**	51	24	18	39
8.929	45	24	20	42	**9.385**	39	22	27	51	**9.818**	36	20	18	33
8.932	55	30	19	39	**9.402**	33	27	30	39	**9.825**	42	19	20	45
8.938	39	20	22	48	**9.408**	39	19	22	48	**9.832**	39	21	27	51
8.941	36	17	19	45	**9.412**	42	21	24	51	**9.844**	42	24	27	48
8.947	17	45	..	19	**9.421**	36	22	19	33	**9.852**	42	18	19	45
8.951	48	33	24	39	**9.429**	33	21	27	45	**9.860**	48	21	22	51
8.956	42	27	19	33	**9.436**	55	24	21	51	**9.868**	45	19	20	48
8.964	48	21	20	51	**9.441**	45	33	27	39	**9.872**	55	30	21	39
8.972	51	24	19	45	**9.446**	39	17	21	51	**9.877**	48	27	20	36
8.980	39	19	21	48	**9.455**	39	30	24	33	**9.882**	36	17	21	45
8.990	33	39	51	48	**9.474**	18	45	..	19	**9.886**	55	24	22	51
9.000	27	42	..	30	**9.481**	48	27	24	45	**9.890**	30	21	27	39
9.015	42	22	17	36	**9.490**	33	17	22	45	**9.894**	51	27	22	42
9.023	30	19	24	42	**9.500**	19	45	..	20	**9.900**	33	20	27	45
9.031	51	20	17	48	**9.506**	55	27	21	45	**9.907**	48	19	20	51
9.048	19	45	..	21	**9.510**	51	33	24	39	**9.917**	30	22	24	33
9.053	55	27	20	45	**9.519**	33	24	27	39	**9.926**	45	24	27	51
9.059	42	30	33	51	**9.524**	20	45	..	21	**9.931**	39	24	22	36
9.066	27	42	55	39	**9.533**	39	20	22	45	**9.935**	51	33	27	42
9.071	55	24	19	48	**9.536**	42	19	22	51	**9.955**	33	17	20	39
9.076	36	21	27	51	**9.545**	21	45	..	22	**9.959**	55	27	22	45
9.081	39	17	19	48	**9.549**	55	24	20	48	**9.965**	36	17	24	51
9.091	30	36	..	33	**9.559**	39	24	30	51	**9.969**	51	27	19	36
9.098	33	19	22	42	**9.563**	51	20	18	48	**9.972**	39	22	27	48
9.102	42	19	21	51	**9.573**	42	27	24	39	**9.989**	55	24	17	39
9.107	51	36	27	42	**9.579**	39	19	21	45	**10.000**	24	45	..	24
9.117	48	27	20	39	**9.586**	45	19	17	42	**10.026**	55	24	21	48
9.123	39	19	20	45	**9.590**	51	30	22	39	**10.031**	36	19	27	51
9.135	45	24	19	39	**9.596**	45	27	19	33	**10.037**	39	17	21	48
9.141	39	24	27	48	**9.600**	48	30	27	45	**10.053**	60	27	19	42
9.148	39	18	19	45	**9.603**	55	30	22	42	**10.065**	42	27	33	51
9.150	42	27	30	51	**9.608**	42	18	21	51	**10.070**	36	22	24	39
9.154	51	30	21	39	**9.613**	51	24	19	42	**10.076**	42	22	19	36
9.167	33	39	..	36	**9.619**	55	27	17	36	**10.084**	45	21	24	51
9.176	39	30	36	51	**9.625**	42	20	22	48	**10.094**	51	20	19	48

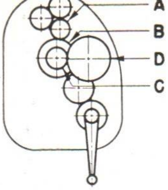


TABLE OF LEADS (10.096 to 11.692)

Lead of Spiral in Inches	A	B	C	D
10.096	45	24	21	39
10.102	33	21	27	42
10.107	42	22	27	51
10.119	55	22	17	42
10.125	36	20	27	48
10.133	48	20	19	45
10.142	51	22	21	48
10.150	30	19	27	42
10.156	39	24	30	48
10.160	60	22	19	51
10.168	33	17	22	42
10.173	42	17	21	51
10.185	55	27	24	48
10.200	51	30	27	45
10.208	42	24	21	36
10.217	45	19	22	51
10.227	36	22	30	48
10.236	48	27	19	33
10.252	55	19	17	48
10.263	39	19	24	48
10.271	55	21	20	51
10.280	42	22	21	39
10.286	48	30	27	42
10.294	55	22	21	51
10.303	51	33	24	36
10.313	45	30	33	48
10.324	45	19	17	39
10.340	48	21	19	42
10.353	51	24	19	39
10.362	45	19	21	48
10.370	42	27	24	36
10.378	39	17	19	42
10.385	45	30	27	39
10.390	48	22	20	42
10.400	39	30	36	45
10.408	51	21	18	42
10.413	36	22	21	33
10.421	33	19	27	45
10.431	42	17	19	45
10.440	45	21	19	39
10.446	55	27	20	39
10.452	33	17	21	39
10.462	48	20	17	39
10.476	22	45	..	21
10.490	45	33	30	39
10.500	21	45	..	20
10.505	39	27	24	33
10.515	39	24	33	51
10.519	36	22	27	42
10.526	20	45	..	19
10.547	45	24	27	48
10.556	19	45	..	18
10.577	33	24	30	39
10.582	60	27	20	42
10.588	18	45	..	17
10.593	39	27	33	45
10.601	55	21	17	42
10.607	33	20	27	42
10.614	33	19	22	36
10.625	51	24	18	36
10.636	39	22	27	45
10.644	60	21	19	51
10.655	51	27	22	39
10.658	36	19	27	48
10.670	55	27	22	42
10.688	33	19	24	39
10.694	42	27	33	48
10.699	51	22	18	39
10.706	42	30	39	51
10.714	33	22	30	42
10.739	42	22	27	48
10.744	39	22	20	33
10.751	55	27	19	36
10.756	48	21	24	51
10.769	42	33	..	39
10.774	48	27	20	33
10.784	45	27	33	51
10.794	51	27	24	42
10.800	36	20	27	45
10.809	42	17	21	48
10.818	51	22	21	45
10.822	55	18	17	48
10.827	36	19	24	42
10.833	39	33	..	36
10.855	45	19	22	48
10.860	30	17	24	39
10.867	39	19	27	51
10.875	51	27	19	33
10.884	48	21	20	42
10.899	42	18	21	45
10.900	45	17	21	51
10.909	36	39	..	33
10.913	55	24	20	42
10.919	33	17	27	48
10.924	39	21	30	51
10.931	30	19	27	39
10.940	48	27	24	39
10.950	33	17	22	39
10.962	45	20	19	39
10.969	55	27	21	39
10.980	42	18	24	51
10.986	51	21	19	42
10.992	42	22	19	33
11.000	33	42	..	30
11.014	45	22	21	39
11.020	36	21	27	42
11.029	45	24	30	51
11.039	51	33	30	42
11.053	21	45	..	19
11.058	55	21	19	45
11.073	48	17	20	51
11.080	39	22	30	48
11.092	36	21	33	51
11.111	30	39	..	27
11.123	39	33	48	51
11.131	51	24	22	42
11.136	42	22	21	36
11.146	36	19	30	51
11.156	51	20	21	48
11.165	55	24	19	39
11.172	39	24	33	48
11.176	19	45	..	17
11.184	45	19	17	36
11.189	48	33	30	39
11.200	42	30	36	45
11.204	55	24	22	45
11.211	36	17	27	51
11.216	39	17	22	45
11.224	45	21	22	42
11.230	42	22	30	51
11.250	27	42	..	24
11.259	48	18	19	45
11.278	45	19	20	42
11.282	55	30	24	39
11.294	51	22	19	39
11.298	55	21	22	51
11.308	42	20	21	39
11.313	42	27	24	33
11 317	55	27	20	36
11.324	42	24	33	51
11.329	36	22	27	39
11.336	42	19	20	39
11.345	45	21	27	51
11.352	55	19	20	51
11.364	45	33	30	36
11.368	36	19	27	45
11.375	42	30	39	48
11.383	55	18	19	51
11.396	60	27	20	39
11.407	42	27	33	45
11.416	55	21	17	39
11.423	33	20	27	39
11.429	24	45	..	21
11.435	39	18	19	36
11.442	51	24	21	39
11.455	42	22	27	45
11.471	39	17	24	48
11.483	36	19	20	33
11.491	55	27	22	39
11.503	48	18	22	51
11.515	60	22	19	45
11.529	42	17	21	45
11.538	45	30	..	39
11.546	39	19	27	48
11.556	39	27	36	45
11.570	42	22	20	33
11.579	22	45	..	19
11.591	51	22	21	42
11 607	39	24	30	42
11.611	55	20	19	45
11.624	51	27	24	39
11.636	48	22	24	45
11.647	33	17	27	45
11.660	36	19	24	39
11.667	42	33	..	36
11.688	60	33	27	42
11.692	48	20	19	39

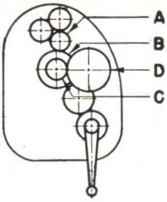


TABLE OF LEADS (11.703 to 13.303)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
11.703	42	19	27	51	**12.217**	45	17	18	39	**12.745**	45	27	39	51
11.719	45	24	30	48	**12.222**	33	39	..	27	**12.750**	51	30	27	36
11.729	39	19	24	42	**12.235**	51	22	19	36	**12.759**	55	21	19	39
11.733	48	20	22	45	**12.245**	45	21	24	42	**12.768**	39	24	33	42
11.743	51	19	21	48	**12.250**	42	20	21	36	**12.773**	48	17	19	42
11.748	42	22	24	39	**12.273**	27	42	..	22	**12.784**	45	22	30	48
11.752	55	24	20	39	**12.281**	42	19	20	36	**12.795**	60	27	19	33
11.765	20	48	..	17	**12.303**	51	19	22	48	**12.800**	48	20	24	45
11.769	51	30	27	39	**12.308**	42	21	24	39	**12.806**	55	17	19	48
11.777	45	22	19	33	**12.316**	39	19	27	45	**12.817**	51	21	19	36
11.789	42	19	24	45	**12.325**	55	21	24	51	**12.821**	55	22	20	39
11.806	55	22	17	36	**12.338**	60	22	19	42	**12.829**	39	19	30	48
11.813	42	20	27	48	**12.346**	60	27	20	36	**12.834**	48	22	30	51
11.818	39	36	..	33	**12.353**	21	45	..	17	**12.857**	27	45	..	21
11.831	51	21	19	39	**12.364**	51	22	24	45	**12.866**	55	19	20	45
11.842	45	19	24	48	**12.375**	33	24	27	30	**12.879**	51	33	30	36
11.846	42	30	33	39	**12.381**	39	27	36	42	**12.891**	45	24	33	48
11.852	48	27	24	36	**12.389**	51	19	18	39	**12.896**	45	17	19	39
11.863	33	17	22	36	**12.397**	45	22	20	33	**12.904**	39	17	27	48
11.868	36	21	27	39	**12.409**	39	22	21	30	**12.919**	30	19	27	33
11.875	51	17	19	48	**12.418**	60	18	19	51	**12.923**	42	20	24	39
11.883	55	27	21	36	**12.423**	51	20	19	39	**12.929**	48	27	24	33
11.889	48	19	24	51	**12.434**	42	19	27	48	**12.941**	22	45	..	17
11.895	42	27	39	51	**12.440**	55	20	19	42	**12.952**	51	21	24	45
11.900	51	20	21	45	**12.449**	55	27	22	36	**12.963**	55	27	21	33
11.905	45	27	30	42	**12.457**	45	17	24	51	**12.981**	45	24	27	39
11.912	36	17	27	48	**12.462**	36	20	27	39	**12.991**	48	18	19	39
11.917	39	30	33	36	**12.467**	51	20	22	45	**13.000**	39	36	..	30
11.922	48	17	19	45	**12.472**	55	21	20	42	**13.017**	45	22	21	33
11.932	42	22	30	48	**12.479**	33	17	27	42	**13.026**	36	19	33	48
11.939	39	21	27	42	**12.487**	55	19	22	51	**13.032**	36	17	24	39
11.946	33	17	24	39	**12.500**	45	33	..	36	**13.040**	51	22	27	48
11.953	51	24	27	48	**12.513**	39	22	36	51	**13.061**	48	21	24	42
11.963	51	18	19	45	**12.526**	51	19	21	45	**13.072**	60	18	20	51
11.973	48	21	22	42	**12.536**	55	27	24	39	**13.080**	42	17	27	51
11.983	55	18	20	51	**12.544**	39	19	22	36	**13.095**	45	27	33	42
11.987	51	24	22	39	**12.549**	48	18	24	51	**13.109**	39	21	36	51
12.000	36	39	..	30	**12.557**	39	33	51	48	**13.117**	36	19	27	39
12.004	55	21	22	48	**12.564**	42	18	21	39	**13.125**	42	24	36	48
12.017	39	21	33	51	**12.571**	36	21	33	45	**13.131**	39	27	30	33
12.024	33	19	27	39	**12.582**	55	18	21	51	**13.149**	45	22	27	42
12.031	42	24	33	48	**12.587**	45	33	36	39	**13.162**	42	27	33	39
12.037	39	27	30	36	**12.593**	51	27	24	36	**13.176**	42	17	24	45
12.042	51	20	17	36	**12.600**	42	20	27	45	**13.181**	55	18	22	51
12.053	55	17	19	51	**12.606**	39	33	48	45	**13.187**	36	21	30	39
12.057	36	19	21	33	**12.618**	55	19	17	39	**13.195**	39	19	27	42
12.063	60	21	19	45	**12.632**	24	45	..	19	**13.200**	36	20	33	45
12.074	39	19	30	51	**12.639**	42	27	39	48	**13.209**	39	17	19	33
12.088	33	21	30	39	**12.656**	45	20	27	48	**13.217**	42	22	27	39
12.095	55	24	19	36	**12.662**	39	22	30	42	**13.223**	48	22	20	33
12.101	48	21	27	51	**12.667**	60	20	19	45	**13.233**	48	19	22	42
12.108	39	17	19	36	**12.675**	51	19	17	36	**13.241**	39	27	33	36
12.115	42	24	27	39	**12.687**	55	17	20	51	**13.247**	51	22	24	42
12.121	60	22	20	45	**12.692**	45	30	33	39	**13.263**	42	19	27	45
12.133	42	30	39	45	**12.698**	48	27	30	42	**13.268**	55	19	22	48
12.149	42	22	21	33	**12.706**	36	17	27	45	**13.281**	51	24	30	48
12.179	60	24	19	39	**12.721**	51	21	22	42	**13.287**	48	17	24	51
12.188	39	22	33	48	**12.727**	42	36	..	33	**13.295**	39	22	36	48
12.201	45	19	17	33	**12.731**	55	24	20	36	**13.303**	42	17	21	39

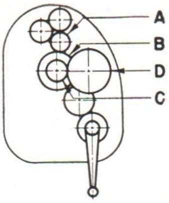


TABLE OF LEADS (13.322 to 15.231)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
13.322	45	19	27	48	**13.929**	39	22	33	42	**14.592**	39	21	33	42
13.333	48	33	..	36	**13.937**	42	17	22	39	**14.599**	42	22	39	51
13.347	51	22	19	33	**13.956**	55	17	22	51	**14.609**	51	24	33	48
13.357	51	20	22	42	**13.971**	60	17	19	48	**14.615**	60	20	19	39
13.368	55	24	21	36	**13.986**	60	33	30	39	**14.625**	39	30	27	24
13.375	48	19	27	51	**14.000**	42	36	..	30	**14.636**	55	17	19	42
13.382	42	24	39	51	**14.005**	55	24	22	36	**14.641**	51	19	18	33
13.388	36	22	27	33	**14.014**	45	17	27	51	**14.652**	60	21	20	39
13.397	55	20	19	39	**14.020**	39	18	33	51	**14.661**	36	17	27	39
13.406	39	20	33	48	**14.026**	48	22	27	42	**14.667**	55	20	24	45
13.421	51	19	24	48	**14.035**	60	19	20	45	**14.682**	51	20	19	33
13.431	55	21	20	39	**14.060**	51	19	22	42	**14.694**	48	21	27	42
13.439	33	17	27	39	**14.066**	48	21	24	39	**14.706**	45	18	30	51
13.445	48	21	30	51	**14.074**	60	18	19	45	**14.712**	51	24	27	39
13.458	51	20	19	36	**14.103**	60	24	22	39	**14.727**	36	22	27	30
13.468	60	27	20	33	**14.112**	39	19	33	48	**14.737**	42	19	30	45
13.474	48	19	24	45	**14.118**	24	48	..	17	**14.748**	39	17	27	42
13.481	42	27	39	45	**14.141**	42	27	30	33	**14.752**	51	22	21	33
13.492	51	27	30	42	**14.152**	55	19	22	45	**14.769**	48	20	24	39
13.500	27	42	..	20	**14.161**	45	22	27	39	**14.774**	55	21	22	39
13.509	42	19	22	36	**14.167**	51	24	30	45	**14.790**	48	21	33	51
13.523	51	24	21	33	**14.182**	39	30	36	33	**14.803**	45	19	30	48
13.534	36	19	30	42	**14.211**	27	42	..	19	**14.808**	42	24	33	39
13.542	45	27	39	48	**14.219**	42	24	39	48	**14.815**	55	27	24	33
13.571	60	20	19	42	**14.225**	42	17	19	33	**14.824**	42	17	27	45
13.580	55	27	24	36	**14.251**	48	19	22	39	**14.835**	45	21	27	39
13.600	51	20	24	45	**14.259**	42	27	33	36	**14.841**	51	27	33	42
13.611	42	18	21	36	**14.266**	51	22	24	39	**14.850**	33	20	27	30
13.622	55	19	24	51	**14.286**	30	39	..	21	**14.861**	48	19	30	51
13.636	45	36	..	33	**14.300**	39	20	33	45	**14.875**	51	20	21	36
13.660	55	17	19	45	**14.316**	51	19	24	45	**14.886**	55	18	19	39
13.670	55	19	17	36	**14.338**	45	24	39	51	**14.890**	45	17	27	48
13.675	48	27	30	39	**14.344**	51	20	27	48	**14.896**	39	36	33	24
13.684	39	19	30	45	**14.351**	39	33	51	42	**14.903**	51	22	27	42
13.700	51	21	22	39	**14.359**	42	27	36	39	**14.928**	39	19	24	33
13.714	48	21	27	45	**14.379**	55	18	24	51	**14.938**	55	27	22	30
13.719	55	21	22	42	**14.385**	51	30	33	39	**14.945**	51	21	24	39
13.725	45	27	42	51	**14.394**	60	24	19	33	**14.954**	51	18	19	36
13.731	51	20	21	39	**14.400**	48	20	27	45	**14.966**	55	21	24	42
13.737	51	27	24	33	**14.405**	55	20	22	42	**14.973**	42	17	20	33
13.750	33	42	..	24	**14.412**	42	17	21	36	**15.000**	45	36	..	30
13.756	48	17	19	39	**14.423**	45	24	30	39	**15.038**	60	19	20	42
13.765	39	17	27	45	**14.429**	55	18	17	36	**15.043**	48	27	33	39
13.776	45	21	27	42	**14.436**	48	19	24	42	**15.053**	39	19	33	45
13.788	42	36	39	33	**14.444**	39	36	..	27	**15.059**	48	17	24	45
13.804	48	17	22	45	**14.453**	51	19	21	39	**15.072**	45	19	21	33
13.816	42	19	30	48	**14.464**	45	20	27	42	**15.079**	60	21	19	36
13.823	55	21	19	36	**14.474**	55	19	24	48	**15.098**	55	17	21	45
13.841	60	17	20	51	**14.480**	48	17	20	39	**15.105**	48	22	27	39
13.846	48	24	27	39	**14.489**	51	22	30	48	**15.111**	51	30	24	27
13.853	48	21	20	33	**14.504**	39	22	27	33	**15.126**	45	21	36	51
13.866	45	21	33	51	**14.514**	55	20	19	36	**15.152**	45	33	30	27
13.878	51	21	24	42	**14.530**	51	27	30	39	**15.158**	48	19	27	45
13.884	42	22	24	33	**14.538**	42	20	27	39	**15.167**	42	36	39	30
13.889	45	27	30	36	**14.545**	48	36	..	33	**15.179**	51	24	30	42
13.897	42	17	27	48	**14.550**	55	27	30	42	**15.195**	39	22	36	42
13.904	39	17	20	33	**14.559**	36	17	33	48	**15.204**	42	17	24	39
13.909	51	30	27	33	**14.571**	51	21	27	45	**15.225**	55	17	24	51
13.919	60	21	19	39	**14.583**	42	36	30	24	**15.231**	36	20	33	39

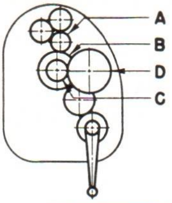


TABLE OF LEADS (15.241 to 17.550)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
15.241	45	17	19	33	**15.966**	60	17	19	42	**16.783**	48	22	30	39
15.256	51	18	21	39	**15.983**	51	27	33	39	**16.794**	39	19	27	33
15.273	42	33	36	30	**16.000**	48	36	..	30	**16.800**	42	20	36	45
15.278	55	24	24	36	**16.032**	36	19	33	39	**16.806**	55	30	33	36
15.294	42	21	39	51	**16.042**	42	36	33	24	**16.813**	51	21	27	39
15.300	51	20	27	45	**16.049**	51	22	27	39	**16.824**	39	17	33	45
15.306	45	21	30	42	**16.071**	45	24	36	42	**16.837**	45	21	33	42
15.311	48	19	20	33	**16.082**	55	19	20	36	**16.845**	45	22	42	51
15.321	39	20	33	42	**16.105**	51	19	27	45	**16.852**	42	36	39	27
15.338	51	19	24	42	**16.117**	55	21	24	39	**16.859**	51	22	24	33
15.354	48	18	19	33	**16.127**	55	18	19	36	**16.875**	45	24	27	30
15.385	45	39	36	27	**16.134**	48	21	36	51	**16.886**	55	19	21	36
15.395	39	19	36	48	**16.150**	51	20	19	30	**16.904**	42	19	39	51
15.400	42	20	33	45	**16.162**	48	33	30	27	**16.917**	45	19	30	42
15.407	39	27	48	45	**16.176**	55	17	24	48	**16.923**	55	20	24	39
15.429	36	21	27	30	**16.190**	51	21	30	45	**16.947**	55	17	22	42
15.439	55	19	24	45	**16.200**	36	20	27	30	**16.970**	42	33	36	27
15.441	42	17	30	48	**16.211**	42	19	33	45	**16.985**	42	17	33	48
15.455	51	36	..	33	**16.239**	60	18	19	39	**17.000**	51	36	..	30
15.469	45	20	33	48	**16.250**	39	36	..	24	**17.017**	45	17	27	42
15.476	45	27	39	42	**16.257**	48	17	19	33	**17.028**	55	19	30	51
15.502	36	19	27	33	**16.283**	55	19	27	48	**17.045**	45	33	30	24
15.513	55	20	22	39	**16.290**	36	17	30	39	**17.053**	36	19	27	30
15.529	36	17	33	45	**16.296**	48	27	33	36	**17.063**	42	20	39	48
15.547	48	19	24	39	**16.313**	51	18	19	33	**17.075**	55	17	19	36
15.556	42	36	..	27	**16.327**	48	21	30	42	**17.081**	51	19	21	33
15.571	45	17	30	51	**16.333**	42	18	21	30	**17.094**	60	27	30	39
15.577	45	20	27	39	**16.346**	51	24	30	39	**17.105**	39	19	30	36
15.587	55	19	21	39	**16.364**	36	39	..	22	**17.112**	48	17	20	33
15.600	39	20	36	45	**16.370**	39	27	51	45	**17.128**	45	17	33	51
15.612	51	21	27	42	**16.387**	45	21	39	51	**17.143**	36	39	..	21
15.620	42	22	27	33	**16.397**	45	19	27	39	**17.172**	51	33	30	27
15.625	45	36	30	24	**16.404**	51	19	22	36	**17.182**	42	22	27	30
15.632	33	19	27	30	**16.410**	48	27	36	39	**17.195**	60	17	19	39
15.642	45	22	39	51	**16.421**	39	19	36	45	**17.206**	39	17	36	48
15.658	51	19	21	36	**16.450**	60	21	19	33	**17.225**	36	19	30	33
15.670	55	27	30	39	**16.471**	42	17	30	45	**17.236**	55	27	33	39
15.686	48	18	30	51	**16.484**	45	21	30	39	**17.255**	55	17	24	45
15.692	51	20	24	39	**16.500**	33	36	..	20	**17.273**	51	17	19	33
15.714	48	24	33	42	**16.508**	48	27	39	42	**17.308**	45	24	36	39
15.724	33	39	..	21	**16.518**	51	19	24	39	**17.316**	60	21	20	33
15.734	45	22	30	39	**16.529**	60	22	20	33	**17.326**	36	17	27	33
15.741	51	27	30	36	**16.544**	45	17	30	48	**17.333**	48	36	39	30
15.750	42	24	27	30	**16.558**	51	22	30	42	**17.347**	51	21	30	42
15.762	55	17	19	39	**16.579**	42	19	36	48	**17.355**	42	33	30	22
15.772	39	17	33	48	**16.593**	42	27	48	45	**17.368**	33	39	..	19
15.789	30	42	..	19	**16.609**	48	17	30	51	**17.376**	48	17	24	39
15.817	55	17	22	45	**16.615**	48	20	27	39	**17.386**	51	24	27	33
15.824	48	21	27	39	**16.623**	48	21	24	33	**17.411**	45	24	39	42
15.833	51	17	19	36	**16.639**	36	17	33	42	**17.421**	55	17	21	39
15.865	45	24	33	39	**16.667**	45	36	..	27	**17.439**	42	17	36	51
15.873	55	21	20	33	**16.684**	48	22	39	51	**17.455**	48	33	36	30
15.882	27	42	..	17	**16.696**	51	24	33	42	**17.471**	33	17	27	30
15.889	39	30	33	27	**16.705**	42	22	21	24	**17.479**	48	21	39	51
15.909	42	33	30	24	**16.714**	39	20	36	42	**17.490**	48	19	27	39
15.918	39	21	36	42	**16.725**	39	19	22	27	**17.500**	42	39	..	24
15.928	48	17	22	39	**16.736**	45	22	27	33	**17.531**	51	20	33	48
15.938	51	20	30	48	**16.762**	48	21	33	45	**17.540**	39	27	51	42
15.955	39	22	27	30	**16.776**	51	19	30	48	**17.550**	39	20	27	30

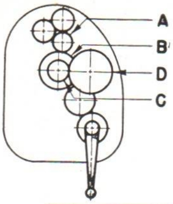


TABLE OF LEADS (17.582 to 20.588)

Lead of Spiral in Inches	A	B	C	D
17.582	48	21	30	39
17.593	60	18	19	36
17.600	48	20	33	45
17.622	42	39	36	22
17.630	42	27	51	45
17.647	30	39	..	17
17.654	51	20	27	39
17.662	51	21	24	33
17.679	45	20	33	42
17.690	55	19	22	36
17.708	51	24	30	36
17.727	39	36	..	22
17.763	45	19	36	48
17.778	48	33	..	27
17.810	51	21	33	45
17.824	55	18	21	36
17.832	51	22	30	39
17.843	42	18	39	51
17.851	48	22	27	33
17.857	60	24	30	42
17.875	39	30	33	24
17.898	45	22	42	48
17.919	36	17	33	39
17.949	45	39	42	27
17.959	48	21	33	42
17.968	42	17	24	33
17.981	51	24	33	39
18.000	36	39	..	20
18.006	55	24	33	42
18.025	39	17	33	42
18.030	51	18	21	33
18.045	48	19	30	42
18.056	45	36	39	27
18.086	42	19	27	33
18.092	55	19	30	48
18.100	60	17	20	39
18.111	45	19	39	51
18.118	42	17	33	45
18.132	45	21	33	39
18.151	48	17	27	42
18.182	48	33	30	24
18.200	42	20	39	45
18.219	45	19	30	39
18.250	55	17	22	39
18.270	48	17	33	51
18.286	48	21	36	45
18.308	42	30	51	39
18.326	45	17	27	39
18.333	55	33	..	30
18.353	39	17	36	45
18.367	45	21	36	42
18.373	48	19	24	33
18.384	42	33	39	27
18.409	45	22	27	30
18.421	55	19	21	33
18.454	51	19	33	48
18.462	48	24	36	39
18.474	39	19	27	30
18.487	55	17	24	42
18.519	60	27	30	36
18.529	42	17	36	48
18.545	51	30	36	33
18.571	39	36	..	21
18.583	51	19	27	39
18.595	45	22	30	33
18.609	45	19	33	42
18.627	60	17	19	36
18.660	39	19	30	33
18.673	55	27	33	36
18.685	45	17	36	51
18.700	51	20	33	45
18.707	55	21	30	42
18.731	55	19	33	51
18.750	45	36	..	24
18.770	39	17	27	33
18.803	55	18	24	39
18.816	39	19	33	36
18.824	48	18	36	51
18.857	48	20	33	42
18.873	55	17	21	36
18.881	45	22	36	39
18.889	51	33	..	27
18.900	42	20	27	30
18.909	48	33	39	30
18.947	36	39	..	19
18.958	42	36	39	24
18.967	51	22	27	33
18.994	45	22	39	42
19.031	55	17	30	51
19.038	45	20	33	39
19.048	55	21	24	33
19.059	36	17	27	30
19.082	51	21	33	42
19.091	42	36	..	22
19.097	55	24	30	36
19.118	45	18	39	51
19.125	51	24	27	30
19.139	60	19	20	33
19.145	48	39	42	27
19.158	42	19	39	45
19.173	51	19	30	42
19.192	60	18	19	33
19.206	55	21	33	45
19.231	55	22	30	39
19.243	45	19	39	48
19.250	42	30	33	24
19.259	48	36	39	27
19.286	45	21	27	30
19.298	55	19	30	45
19.319	48	19	39	51
19.341	48	21	33	39
19.378	45	19	27	33
19.385	42	20	36	39
19.394	48	33	36	27
19.412	33	36	..	17
19.429	51	21	36	45
19.433	48	19	30	39
19.444	45	36	42	27
19.479	51	24	33	36
19.500	39	36	..	20
19.522	51	19	24	33
19.548	48	17	27	39
19.556	48	30	33	27
19.592	48	21	36	42
19.608	60	17	20	36
19.615	51	24	36	39
19.636	48	22	27	30
19.643	33	21	30	24
19.664	39	17	36	42
19.684	51	19	33	45
19.697	45	33	39	27
19.732	51	24	39	42
19.744	42	18	33	39
19.765	42	17	36	45
19.780	45	21	36	39
19.800	36	30	33	20
19.810	48	21	39	45
19.835	48	22	30	33
19.850	48	19	33	42
19.861	39	27	33	24
19.870	51	22	36	42
19.895	42	19	27	30
19.910	55	17	24	39
19.922	45	24	51	48
19.931	48	17	36	51
20.000	48	36	..	24
20.040	45	19	33	39
20.074	42	17	39	48
20.096	42	19	30	33
20.132	51	19	36	48
20.147	55	21	30	39
20.167	55	20	22	30
20.192	45	39	42	24
20.202	60	27	30	33
20.211	48	19	24	30
20.222	42	30	39	27
20.238	51	21	30	36
20.250	45	20	27	30
20.260	39	33	36	21
20.301	45	19	36	42
20.321	60	17	19	33
20.342	42	27	51	39
20.362	45	17	30	39
20.370	55	33	..	27
20.392	48	18	39	51
20.400	51	20	24	30
20.408	60	21	30	42
20.433	55	19	36	51
20.455	45	36	..	22
20.463	51	36	39	27
20.513	45	27	48	39
20.526	39	36	..	19
20.535	48	17	24	33
20.549	51	21	33	39
20.571	48	21	27	30
20.578	55	21	33	42
20.588	55	17	21	33

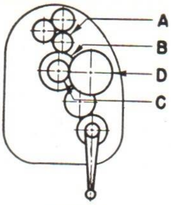


TABLE OF LEADS (20.606 to 24.740)

Lead of Spiral in Inches	A	B	C	D
20.606	51	33	36	27
20.625	45	30	33	24
20.635	39	21	30	27
20.648	51	19	30	39
20.670	48	19	27	33
20.682	42	33	39	24
20.706	48	17	33	45
20.719	51	20	39	48
20.741	48	36	42	27
20.769	45	20	36	39
20.778	51	30	33	27
20.798	45	17	33	42
20.805	48	19	42	51
20.816	51	21	36	42
20.826	42	33	36	22
20.833	45	27	30	24
20.842	36	30	33	19
20.856	39	17	30	33
20.864	51	22	27	30
20.905	42	17	33	39
20.934	55	17	33	51
20.952	48	21	33	36
20.979	60	22	30	39
21.000	42	39	..	20
21.010	48	33	39	27
21.029	39	17	33	36
21.053	55	19	24	33
21.074	51	22	30	33
21.099	48	21	36	39
21.154	55	20	30	39
21.176	36	39	..	17
21.212	45	33	42	27
21.228	55	19	22	30
21.250	51	33	..	24
21.273	39	30	36	22
21.316	45	19	27	30
21.333	48	30	36	27
21.377	48	19	33	39
21.389	42	27	33	24
21.399	51	22	36	39
21.412	42	17	39	45
21.429	45	36	..	21
21.450	39	30	33	20
21.474	51	19	36	45
21.507	45	17	39	48
21.526	51	22	39	42
21.538	48	24	42	39
21.577	51	20	33	39
21.592	48	17	39	51
21.607	55	20	33	42
21.636	51	33	42	30
21.654	48	19	36	42
21.667	39	36	..	18
21.711	55	19	36	48
21.719	48	17	30	39
21.795	51	18	30	39
21.809	51	19	39	48
21.818	48	33	..	22
21.825	55	21	30	36
21.857	51	21	27	30
21.862	45	19	36	39
21.875	45	36	42	24
21.895	48	19	39	45
21.962	51	19	27	33
21.978	60	21	30	39
22.000	48	30	33	24
22.028	45	39	42	22
22.037	42	27	51	36
22.059	45	17	30	36
22.068	39	36	55	27
22.078	51	21	30	33
22.105	42	36	..	19
22.154	48	20	36	39
22.185	48	17	33	42
22.222	48	36	45	27
22.235	42	17	27	30
22.243	55	17	33	48
22.262	51	21	33	36
22.286	39	30	36	21
22.313	51	20	42	48
22.323	51	33	39	27
22.344	39	24	33	24
22.368	51	19	30	36
22.392	39	33	36	19
22.400	48	20	42	45
22.418	51	21	36	39
22.449	55	21	36	42
22.460	42	17	30	33
22.500	45	36	..	20
22.551	51	21	39	42
22.564	48	18	33	39
22.579	39	30	33	19
22.588	48	17	36	45
22.626	42	27	48	33
22.667	51	30	36	27
22.689	45	17	36	42
22.698	39	27	33	21
22.713	51	19	33	39
22.727	45	27	30	22
22.737	48	19	27	30
22.744	55	19	33	42
22.750	42	30	39	24
22.768	51	21	45	48
22.805	42	17	36	39
22.837	55	17	36	51
22.857	48	33	..	21
22.885	51	24	42	39
22.909	42	30	36	22
22.917	55	30	..	24
22.941	39	36	..	17
22.967	48	19	30	33
23.008	51	19	36	42
23.021	51	24	39	36
23.077	48	24	45	39
23.100	42	30	33	20
23.111	48	30	39	27
23.158	55	19	24	30
23.182	51	33	..	22
23.214	45	36	39	21
23.253	48	17	42	51
23.269	55	20	33	39
23.294	36	17	33	30
23.320	48	19	36	39
23.333	42	36	..	18
23.375	51	30	33	24
23.400	39	30	36	20
23.437	45	24	30	24
23.459	48	19	39	42
23.487	51	19	42	48
23.504	55	18	30	39
23.529	55	17	24	33
23.538	51	20	36	39
23.579	48	19	42	45
23.611	51	27	30	24
23.636	48	33	39	24
23.684	45	33	..	19
23.725	55	17	22	30
23.765	42	27	55	36
23.800	51	20	42	45
23.810	45	21	30	27
23.824	45	17	27	30
23.833	39	27	33	20
23.864	45	33	42	24
23.891	48	17	33	39
23.947	42	19	39	36
23.974	51	18	33	39
24.000	48	33	..	20
24.040	51	33	42	27
24.063	42	24	33	24
24.074	55	27	39	33
24.115	42	33	36	19
24.123	55	19	30	36
24.158	51	19	27	30
24.176	55	21	36	39
24.202	48	17	36	42
24.231	45	20	42	39
24.242	48	33	45	27
24.265	55	17	36	48
24.286	51	33	..	21
24.292	60	19	30	39
24.316	42	30	33	19
24.375	45	30	39	24
24.402	51	19	30	33
24.434	45	17	36	39
24.444	55	30	36	27
24.471	48	17	39	45
24.494	55	19	33	39
24.519	45	24	51	39
24.545	45	30	36	22
24.561	42	19	30	27
24.580	45	17	39	42
24.605	51	19	33	36
24.615	48	21	42	39
24.632	39	30	36	19
24.706	42	36	..	17
24.727	48	22	51	45
24.740	55	17	39	51

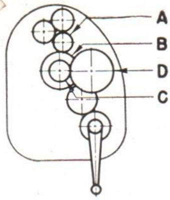


TABLE OF LEADS (24.750 to 30.390)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
24.750	45	30	33	20	**26.353**	48	17	42	45	**28.373**	55	21	39	36
24.762	39	27	36	21	**26.374**	48	21	45	39	**28.421**	45	30	36	19
24.777	51	19	36	39	**26.400**	48	30	33	20	**28.437**	42	24	39	24
24.793	60	22	30	33	**26.442**	45	24	55	39	**28.507**	45	17	42	39
24.826	55	24	39	36	**26.471**	45	36	..	17	**28.519**	55	27	42	30
24.887	55	17	30	39	**26.494**	51	33	36	21	**28.547**	55	17	45	51
24.914	48	17	45	51	**26.526**	42	30	36	19	**28.571**	48	21	30	24
24.925	51	19	39	42	**26.535**	55	19	33	36	**28.636**	45	30	42	22
24.935	48	33	36	21	**26.591**	45	30	39	22	**28.676**	45	36	39	17
24.965	51	22	42	39	**26.644**	55	17	42	51	**28.701**	51	33	39	21
25.000	51	17	30	36	**26.667**	48	36	..	18	**28.718**	48	18	42	39
25.027	39	33	36	17	**26.714**	51	30	33	21	**28.737**	42	30	39	19
25.053	51	19	42	45	**26.748**	51	22	45	39	**28.759**	51	19	45	42
25.088	39	27	33	19	**26.765**	42	36	39	17	**28.810**	55	30	33	21
25.114	51	33	39	24	**26.786**	45	21	30	24	**28.875**	42	24	33	20
25.143	48	30	33	21	**26.812**	39	24	33	20	**28.889**	48	27	39	24
25.175	48	22	45	39	**26.842**	51	33	..	19	**28.907**	51	19	42	39
25.200	42	30	36	20	**26.880**	55	19	39	42	**28.947**	45	27	33	19
25.210	60	17	30	42	**26.952**	42	33	36	17	**28.977**	51	24	45	33
25.235	39	17	33	30	**26.984**	51	21	30	27	**29.079**	51	19	39	36
25.263	48	33	..	19	**27.000**	45	30	36	20	**29.091**	48	33	42	21
25.278	42	27	39	24	**27.018**	42	27	33	19	**29.101**	55	21	30	27
25.289	51	33	36	22	**27.045**	51	33	42	24	**29.118**	45	17	33	30
25.325	45	33	39	21	**27.068**	48	19	45	42	**29.143**	51	30	36	21
25.385	60	20	33	39	**27.083**	55	24	39	33	**29.167**	45	27	42	24
25.397	48	21	30	27	**27.149**	60	17	30	39	**29.198**	42	33	39	17
25.412	48	17	27	30	**27.176**	42	17	33	30	**29.221**	45	21	30	22
25.420	55	17	33	42	**27.206**	48	19	42	39	**29.250**	45	30	39	20
25.455	48	33	42	24	**27.273**	48	33	45	24	**29.282**	51	33	36	19
25.463	55	27	30	24	**27.300**	42	30	39	20	**29.333**	48	27	33	20
25.490	39	17	30	27	**27.368**	39	27	36	19	**29.412**	60	17	30	36
25.500	51	33	..	20	**27.397**	51	33	39	22	**29.423**	51	20	45	39
25.536	39	24	33	21	**27.429**	48	30	36	21	**29.474**	42	27	36	19
25.568	45	24	30	22	**27.462**	51	20	42	39	**29.504**	51	22	42	33
25.641	60	18	30	39	**27.500**	55	33	..	20	**29.526**	51	30	33	19
25.658	45	36	39	19	**27.529**	39	30	36	17	**29.545**	45	27	39	22
25.668	48	17	30	33	**27.560**	48	33	36	19	**29.605**	45	19	30	24
25.714	45	30	36	21	**27.576**	42	27	39	22	**29.630**	48	18	30	27
25.758	51	27	30	22	**27.632**	45	19	42	36	**29.657**	55	17	33	36
25.785	48	33	39	22	**27.692**	48	20	45	39	**29.683**	51	27	33	21
25.837	45	33	36	19	**27.731**	55	17	36	42	**29.714**	48	30	39	21
25.846	48	20	42	39	**27.755**	51	21	48	42	**29.750**	51	30	42	24
25.855	55	18	33	39	**27.769**	48	33	42	22	**29.774**	36	21	33	19
25.882	55	17	36	45	**27.789**	48	30	33	19	**29.792**	55	30	39	24
25.905	51	21	48	45	**27.818**	51	30	36	22	**29.825**	51	19	30	27
25.926	42	18	30	27	**27.857**	45	30	39	21	**29.864**	55	17	36	39
25.972	51	27	33	24	**27.937**	48	27	33	21	**29.890**	51	21	48	39
26.000	48	30	39	24	**27.990**	45	33	39	19	**30.000**	55	30	36	22
26.020	51	21	45	42	**28.009**	55	27	33	24	**30.042**	55	17	39	42
26.033	45	33	42	22	**28.022**	51	21	45	39	**30.136**	51	30	39	22
26.053	45	30	33	19	**28.039**	55	17	39	45	**30.144**	45	33	42	19
26.063	48	17	36	39	**28.050**	51	30	33	20	**30.196**	42	17	33	27
26.124	42	33	39	19	**28.070**	48	19	30	27	**30.222**	51	30	48	27
26.154	51	21	42	39	**28.125**	45	24	36	24	**30.252**	48	17	45	42
26.182	48	30	36	22	**28.224**	39	24	33	19	**30.303**	60	22	30	27
26.218	48	17	39	42	**28.235**	48	36	..	17	**30.316**	48	30	36	19
26.250	45	30	42	24	**28.283**	60	27	42	33	**30.333**	42	27	39	20
26.287	55	17	39	48	**28.309**	55	17	42	48	**30.357**	51	21	30	24
26.310	51	21	39	36	**28.333**	51	27	33	22	**30.390**	39	22	36	21

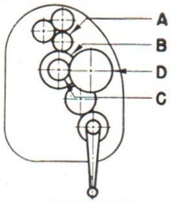


TABLE OF LEADS (30.407 to 37.227)

Lead of Spiral in Inches	A	B	C	D
30.407	48	17	42	39
30.450	55	17	48	51
30.476	48	27	36	21
30.513	51	18	42	39
30.545	48	30	42	22
30.556	55	24	36	27
30.588	39	17	36	27
30.600	51	30	36	20
30.643	39	20	33	21
30.677	51	19	48	42
30.694	51	27	39	24
30.769	48	18	45	39
30.789	45	30	39	19
30.802	48	33	36	17
30.882	45	36	42	17
30.909	51	27	36	22
30.937	45	24	33	20
30.952	45	27	39	21
30.972	51	19	45	39
31.023	42	24	39	22
31.059	48	17	33	30
31.111	48	27	42	24
31.167	51	27	33	20
31.200	48	30	39	20
31.250	60	24	30	24
31.283	45	33	39	17
31.316	51	19	42	36
31.360	55	19	39	36
31.385	51	20	48	39
31.429	55	30	36	21
31.481	51	18	30	27
31.500	45	30	42	20
31.515	48	27	39	22
31.544	39	17	33	24
31.571	51	30	39	21
31.612	51	22	45	33
31.722	51	33	39	19
31.746	60	21	30	27
31.765	45	30	36	17
31.818	45	27	42	22
31.842	55	30	33	19
31.875	51	30	45	24
31.909	39	22	36	20
31.930	42	27	39	19
32.000	48	21	42	30
32.011	55	27	33	21
32.083	42	18	33	24
32.118	42	30	39	17
32.143	45	24	36	21
32.164	55	19	30	27
32.211	51	30	36	19
32.231	60	22	39	33
32.256	39	19	33	21
32.297	45	19	30	22
32.308	51	17	42	39
32.353	45	17	33	27
32.381	51	27	36	21
32.455	51	30	42	22
32.500	48	24	39	24
32.566	45	24	33	19
32.579	48	17	45	39
32.692	51	18	45	39
32.727	51	33	36	17
32.738	55	21	30	24
32.807	51	27	33	19
32.842	48	30	39	19
32.906	55	18	42	39
32.941	42	27	36	17
33.000	48	24	33	20
33.016	48	27	39	21
33.036	51	19	48	39
33.056	51	27	42	24
33.088	45	17	30	24
33.117	51	21	30	22
33.158	45	30	42	19
33.239	45	24	39	22
33.277	36	17	33	21
33.333	55	27	36	22
33.369	48	33	39	17
33.393	51	24	33	21
33.429	39	21	36	20
33.485	51	27	39	22
33.553	51	19	30	24
33.589	39	22	36	19
33.611	55	27	33	20
33.684	48	27	36	19
33.704	42	27	39	18
33.719	51	22	48	33
33.750	45	24	36	20
33.772	55	19	42	36
33.846	48	20	55	39
33.868	39	19	33	20
33.882	48	30	36	17
33.939	48	27	42	22
33.951	55	18	30	27
33.971	42	17	33	24
34.000	51	30	48	24
34.048	55	30	39	21
34.091	55	22	45	33
34.125	42	24	39	20
34.163	51	19	42	33
34.211	45	27	39	19
34.249	51	21	55	39
34.286	48	24	36	21
34.375	55	30	45	24
34.412	45	30	39	17
34.450	48	19	30	22
34.510	48	17	33	27
34.531	51	24	39	24
34.615	51	17	45	39
34.630	51	18	33	27
34.667	48	27	39	20
34.711	60	22	42	33
34.737	48	19	33	24
34.773	51	30	45	22
34.821	45	24	39	21
34.842	55	17	42	39
34.872	51	18	48	39
34.895	51	30	39	19
34.921	55	27	36	21
35.000	48	24	42	24
35.049	55	17	39	36
35.065	45	22	36	21
35.079	51	27	39	21
35.088	60	19	30	27
35.188	39	21	36	19
35.256	55	18	45	39
35.294	45	27	36	17
35.325	51	21	48	33
35.357	45	21	33	20
35.368	48	30	42	19
35.380	55	27	33	19
35.417	51	27	45	24
35.455	42	22	39	21
35.526	45	24	36	19
35.556	48	27	42	21
35.588	55	17	33	30
35.648	55	27	42	24
35.686	42	27	39	17
35.700	51	30	42	20
35.714	60	21	30	24
35.750	55	20	39	30
35.795	45	24	42	22
35.921	42	24	39	19
35.936	48	17	42	33
35.948	55	17	30	27
35.962	51	20	55	39
36.000	51	30	36	17
36.012	55	24	33	21
36.050	39	17	33	21
36.061	51	27	42	22
36.096	45	17	30	22
36.111	55	27	39	22
36.172	42	22	36	19
36.184	55	19	45	36
36.364	48	27	45	22
36.397	45	17	33	24
36.429	51	30	45	21
36.474	42	19	33	20
36.491	48	27	39	19
36.562	45	24	39	20
36.603	51	19	45	33
36.667	55	27	36	20
36.706	48	30	39	17
36.818	45	22	36	20
36.842	55	19	42	33
36.908	51	24	33	19
36.923	51	17	48	39
36.947	39	20	36	19
36.975	55	17	48	42
37.037	60	18	30	27
37.059	45	30	42	17
37.091	51	22	48	30
37.143	48	24	39	21
37.187	51	24	42	24
37.218	45	21	33	19
37.227	42	22	39	20

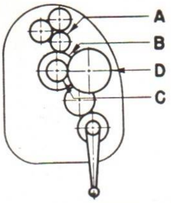


TABLE OF LEADS (37.240 to 46.324)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
37.240	55	24	39	24	**40.000**	51	27	36	17	**43.105**	42	20	39	19
37.321	60	19	39	33	**40.071**	51	21	33	20	**43.137**	55	27	36	17
37.346	55	18	33	27	**40.104**	55	24	42	24	**43.175**	51	27	48	21
37.403	48	22	36	21	**40.147**	42	24	39	17	**43.214**	55	21	33	20
37.500	55	24	36	22	**40.191**	60	19	42	33	**43.308**	48	21	36	19
37.540	39	17	36	22	**40.263**	51	24	36	19	**43.333**	51	27	39	17
37.579	51	30	42	19	**40.428**	42	22	36	17	**43.421**	55	19	36	24
37.632	55	19	39	30	**40.441**	55	17	45	36	**43.466**	51	24	45	22
37.647	48	27	36	17	**40.476**	51	27	45	21	**43.618**	51	24	39	19
37.670	51	24	39	22	**40.519**	48	22	39	21	**43.636**	48	22	42	21
37.714	48	21	33	20	**40.568**	51	24	42	22	**43.651**	55	21	45	27
37.745	55	17	42	36	**40.602**	45	21	36	19	**43.676**	45	17	33	20
37.778	51	27	48	24	**40.625**	60	24	39	24	**43.714**	51	21	36	20
37.812	55	24	33	20	**40.741**	55	27	42	21	**43.750**	60	24	42	24
37.831	55	27	39	21	**40.765**	42	17	33	20	**43.797**	42	22	39	17
37.853	39	17	33	20	**40.784**	48	27	39	17	**43.923**	51	22	36	19
37.895	48	30	45	19	**40.800**	51	20	48	30	**43.985**	45	21	39	19
37.917	42	24	39	18	**40.909**	60	20	30	22	**44.000**	48	18	33	20
37.987	45	22	39	21	**40.926**	51	27	39	18	**44.074**	51	27	42	18
38.182	48	24	42	22	**41.053**	48	24	39	19	**44.118**	60	17	30	24
38.194	55	27	45	24	**41.143**	48	21	36	20	**44.136**	55	18	39	27
38.235	45	27	39	17	**41.176**	45	27	42	17	**44.211**	48	24	42	19
38.250	51	24	36	20	**41.212**	51	27	48	22	**44.289**	51	20	33	19
38.487	45	24	39	19	**41.250**	55	24	36	20	**44.318**	60	24	39	22
38.500	55	20	42	30	**41.270**	60	21	39	27	**44.370**	48	17	33	21
38.519	48	27	39	18	**41.294**	39	17	36	20	**44.444**	48	27	45	18
38.571	45	21	36	20	**41.340**	48	22	36	19	**44.471**	42	20	36	17
38.596	55	27	36	19	**41.364**	42	22	39	18	**44.485**	55	17	33	24
38.636	51	27	45	22	**41.437**	51	24	39	20	**44.524**	51	18	33	21
38.756	45	22	36	19	**41.481**	48	27	42	18	**44.571**	48	21	39	20
38.772	51	27	39	19	**41.597**	45	17	33	21	**44.625**	51	24	42	20
38.824	48	17	33	24	**41.667**	55	27	45	22	**44.687**	55	24	39	20
38.857	51	30	48	21	**41.684**	48	19	33	20	**44.737**	51	27	45	19
38.889	60	24	42	27	**41.711**	60	17	39	33	**44.785**	48	22	39	19
38.958	51	18	33	24	**41.727**	51	22	36	20	**44.920**	60	17	42	33
39.000	51	30	39	17	**41.754**	51	27	42	19	**45.000**	55	22	36	20
39.043	51	19	48	33	**41.786**	45	21	39	20	**45.029**	55	19	42	27
39.079	45	20	33	19	**41.813**	55	27	39	19	**45.205**	51	22	39	20
39.187	42	22	39	19	**41.905**	48	18	33	21	**45.215**	45	22	42	19
39.216	60	17	30	27	**41.986**	45	22	39	19	**45.294**	55	17	42	30
39.273	48	22	36	20	**42.000**	48	24	42	20	**45.333**	51	27	48	20
39.286	55	22	33	21	**42.014**	55	18	33	24	**45.378**	45	21	36	17
39.298	48	27	42	19	**42.059**	55	17	39	30	**45.455**	60	22	45	27
39.328	39	17	36	21	**42.105**	48	27	45	19	**45.474**	48	20	36	19
39.375	45	24	42	20	**42.180**	51	21	33	19	**45.489**	55	21	33	19
39.394	60	22	39	27	**42.308**	55	17	51	39	**45.500**	42	20	39	18
39.464	51	24	39	21	**42.353**	48	30	45	17	**45.536**	51	24	45	21
39.474	55	19	45	33	**42.424**	60	22	42	27	**45.614**	60	19	39	27
39.529	48	30	42	17	**42.500**	51	27	45	20	**45.714**	48	21	36	18
39.542	55	17	33	27	**42.545**	48	22	39	20	**45.818**	48	22	42	20
39.667	51	27	42	20	**42.560**	55	24	39	21	**45.833**	55	24	48	24
39.699	48	21	33	19	**42.632**	45	20	36	19	**45.882**	48	24	39	17
39.722	55	27	39	20	**42.778**	55	27	42	20	**45.975**	45	17	33	19
39.740	51	22	36	21	**42.910**	42	17	33	19	**46.015**	51	21	36	19
39.789	42	20	36	19	**42.947**	51	19	48	30	**46.042**	51	24	39	18
39.803	55	24	33	19	**42.969**	55	24	45	24	**46.184**	45	20	39	19
39.819	55	17	48	39	**43.015**	45	24	39	17	**46.203**	48	22	36	17
39.845	39	17	33	19	**43.052**	51	22	39	21	**46.316**	48	18	33	19
39.886	45	22	39	20	**43.062**	60	19	30	22	**46.324**	45	24	42	17

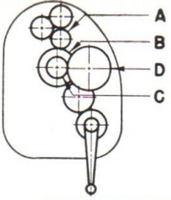


TABLE OF LEADS (46.364 to 60.662)

Lead of Spiral in Inches	A	B	C	D
46.364	51	24	48	22
46.429	60	24	39	21
46.561	55	21	48	27
46.588	48	17	33	20
46.667	51	27	42	17
46.732	55	27	39	17
46.753	48	21	45	22
46.811	42	17	36	19
46.875	60	24	45	24
46.925	45	22	39	17
46.974	51	24	42	19
47.039	55	24	39	19
47.059	48	27	45	17
47.143	55	21	36	20
47.222	51	27	45	18
47.273	48	22	39	18
47.357	51	21	39	20
47.531	55	18	42	27
47.584	51	22	39	19
47.619	60	21	45	27
47.647	45	20	36	17
47.719	51	27	48	19
47.763	55	20	33	19
47.812	51	24	45	20
47.895	42	19	39	18
48.000	48	21	42	20
48.016	55	18	33	21
48.125	55	24	42	20
48.148	60	18	39	27
48.176	42	20	39	17
48.230	48	22	42	19
48.246	55	19	45	27
48.316	51	20	36	19
48.403	48	21	36	17
48.485	60	22	48	27
48.529	55	24	36	17
48.571	51	24	48	21
48.698	55	24	51	24
48.750	55	22	39	20
48.889	55	20	48	27
49.040	48	17	33	19
49.091	51	22	36	17
49.107	55	24	45	21
49.123	60	19	42	27
49.160	45	21	39	17
49.211	55	19	51	30
49.263	48	20	39	19
49.412	60	17	42	30
49.471	55	21	51	27
49.500	51	17	33	20
49.524	48	21	39	18
49.583	51	24	42	18
49.624	55	21	36	19
49.653	55	24	39	18
49.675	51	22	45	21
49.737	45	20	42	19
49.850	51	21	39	19
50.000	55	24	48	22
50.053	48	22	39	17
50.155	45	19	36	17
50.227	51	22	39	18
50.329	51	24	45	19
50.370	51	27	48	18
50.417	55	18	33	20
50.526	48	21	42	19
50.649	60	22	39	21
50.712	42	19	39	17
50.794	60	21	48	27
50.824	48	20	36	17
50.840	55	17	33	21
50.909	48	22	42	18
50.926	55	18	45	27
50.980	60	17	39	27
51.000	51	24	48	20
51.071	55	21	39	20
51.136	60	22	45	24
51.244	51	19	42	22
51.316	55	22	39	19
51.429	48	21	45	20
51.462	55	19	48	27
51.562	55	24	45	20
51.618	45	20	39	17
51.675	48	22	45	19
51.852	60	18	42	27
51.944	55	20	51	27
52.000	48	20	39	18
52.105	55	20	36	19
52.159	51	22	45	20
52.342	51	20	39	19
52.381	55	24	48	21
52.437	48	21	39	17
52.500	55	22	42	20
52.574	55	24	39	17
52.632	60	19	45	27
52.941	48	24	45	17
52.987	51	22	48	21
53.053	48	20	42	19
53.070	55	18	33	19
53.125	55	24	51	22
53.182	60	22	39	20
53.333	51	27	48	17
53.382	55	17	33	20
53.472	55	24	42	18
53.498	48	19	36	17
53.529	42	18	39	17
53.571	55	22	45	21
53.684	51	24	48	19
53.759	55	21	39	19
53.904	48	22	42	17
53.922	55	17	45	27
54.000	51	20	36	17
54.091	51	22	42	18
54.135	48	21	45	19
54.167	55	22	39	18
54.276	55	19	45	24
54.321	55	18	48	27
54.334	45	19	39	17
54.545	60	22	48	24
54.643	51	21	45	20
54.678	55	19	51	27
54.737	48	19	39	18
54.902	60	17	42	27
55.000	55	24	48	20
55.059	48	20	39	17
55.250	51	20	39	18
55.263	55	22	42	19
55.462	55	21	36	17
55.556	60	18	45	27
55.588	45	20	42	17
55.636	51	22	48	20
55.655	55	24	51	21
55.714	60	21	39	20
55.981	60	22	39	19
56.000	48	20	42	18
56.140	60	19	48	27
56.192	55	17	33	19
56.250	55	22	45	20
56.368	51	20	42	19
56.447	55	20	39	19
56.471	48	21	42	17
56.618	55	24	42	17
56.667	51	24	48	18
56.746	55	21	39	18
56.842	51	19	36	17
57.143	55	22	48	21
57.273	60	22	42	20
57.292	55	24	45	18
57.353	55	22	39	17
57.519	51	21	45	19
57.716	55	18	51	27
57.754	48	22	45	17
57.895	55	24	48	19
57.957	48	19	39	17
58.158	51	19	39	18
58.235	55	20	36	17
58.286	51	21	48	20
58.333	55	22	42	18
58.437	55	24	51	20
58.500	51	20	39	17
58.514	45	19	42	17
58.565	51	22	48	19
58.647	60	21	39	19
58.824	60	17	45	27
58.929	55	21	45	20
58.947	48	19	42	18
59.091	60	22	39	18
59.211	55	22	45	19
59.259	60	18	48	27
59.294	48	20	42	17
59.500	51	20	42	18
59.583	55	20	39	18
60.000	60	21	42	20
60.084	55	21	39	17
60.287	60	19	42	22
60.395	51	20	45	19
60.504	48	21	45	17
60.662	55	17	45	24

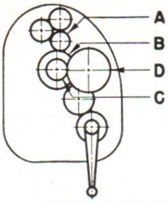


TABLE OF LEADS (60.714 to 107.843)

Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D	Lead of Spiral in Inches	A	B	C	D
60.714	55	22	51	21	**66.873**	48	19	45	17	**76.471**	60	18	39	17
60.789	55	20	42	19	**67.105**	55	22	51	19	**76.625**	55	19	45	17
61.111	55	21	42	18	**67.380**	60	17	42	22	**76.692**	60	19	51	21
61.176	48	18	39	17	**67.500**	51	20	45	17	**77.005**	60	17	48	22
61.300	55	19	36	17	**67.554**	55	19	42	18	**77.193**	55	19	48	18
61.364	51	22	45	17	**67.669**	60	19	45	21	**77.273**	60	18	51	22
61.513	55	19	51	24	**67.941**	55	20	42	17	**77.647**	55	20	48	17
61.579	60	20	39	19	**68.000**	51	20	48	18	**77.917**	55	20	51	18
61.765	55	22	42	17	**68.182**	60	18	45	22	**78.019**	60	19	42	17
61.818	51	22	48	18	**68.421**	60	19	39	18	**78.571**	55	21	51	17
61.905	60	21	39	18	**68.571**	60	20	48	21	**78.947**	60	18	45	19
62.030	55	21	45	19	**68.750**	55	20	45	18	**79.412**	60	17	45	20
62.338	60	21	48	22	**68.824**	60	20	39	17	**80.000**	51	18	48	17
62.415	48	19	42	17	**68.900**	60	19	48	22	**80.526**	60	19	51	20
62.500	55	22	45	18	**69.328**	55	21	45	17	**80.672**	60	17	48	21
62.567	60	22	39	17	**69.474**	55	20	48	19	**80.882**	55	18	45	17
62.632	51	19	42	18	**69.545**	60	20	51	22	**80.952**	60	18	51	21
62.719	55	19	39	18	**69.841**	55	21	48	18	**81.734**	55	19	48	17
62.745	60	17	48	27	**70.000**	60	20	42	18	**81.818**	60	17	51	22
62.857	55	21	48	20	**70.098**	55	18	39	17	**82.018**	55	19	51	18
62.963	60	18	51	27	**70.301**	55	21	51	19	**82.353**	60	18	42	17
63.000	51	20	42	17	**70.588**	55	22	48	17	**82.500**	55	20	51	17
63.088	55	20	39	17	**70.833**	55	22	51	18	**82.707**	60	19	55	21
63.158	55	22	48	19	**71.053**	60	19	45	20	**83.333**	60	18	55	22
63.529	48	20	45	17	**71.429**	60	18	45	21	**83.591**	60	19	45	17
63.636	60	18	42	22	**71.517**	55	19	42	17	**84.211**	60	18	48	19
63.750	55	22	51	20	**71.579**	51	19	48	18	**84.706**	60	17	48	20
64.167	55	18	42	20	**72.000**	51	20	48	17	**85.000**	60	18	51	20
64.286	60	21	45	20	**72.180**	60	19	48	21	**85.714**	60	17	51	21
64.421	51	20	48	19	**72.368**	55	19	45	18	**86.275**	55	18	48	17
64.593	60	19	45	22	**72.446**	60	19	39	17	**86.842**	55	19	51	17
64.706	55	21	42	17	**72.727**	60	18	48	22	**87.302**	60	18	55	21
64.762	51	21	48	18	**72.794**	55	20	45	17	**88.235**	60	18	45	17
64.931	55	18	51	24	**72.857**	60	20	51	21	**89.164**	60	17	48	19
65.000	60	20	39	18	**73.206**	60	19	51	22	**89.474**	60	18	51	19
65.132	55	20	45	19	**73.333**	55	20	48	18	**90.000**	60	17	51	20
65.455	60	20	48	22	**73.684**	60	19	42	18	**91.667**	60	18	55	20
65.476	55	21	45	18	**73.816**	55	20	51	19	**92.437**	60	17	55	21
65.546	60	21	39	17	**73.950**	55	21	48	17	**94.118**	60	18	48	17
65.882	48	18	42	17	**74.118**	60	20	42	17	**94.737**	60	17	51	19
66.165	55	21	48	19	**74.206**	55	21	51	18	**96.491**	60	18	55	19
66.234	60	21	51	22	**75.000**	55	22	51	17	**97.059**	60	17	55	20
66.316	60	20	42	19	**75.490**	55	18	42	17	**100.000**	60	17	51	18
66.409	55	19	39	17	**75.630**	60	17	45	21	**102.167**	60	17	55	19
66.667	60	21	42	18	**75.789**	51	19	48	17	**107.843**	60	17	55	18
66.786	55	21	51	20	**76.190**	60	18	48	21					

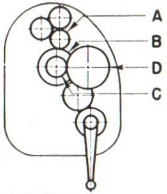


TABLE OF CHANGE GEARS, APPROXIMATE ANGLES AND ENGLISH LEADS FOR CUTTING SPIRALS

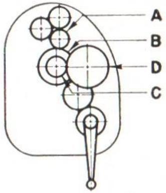
Lead of Spiral Inches	A	B	C	D	DIAMETER OF WORK																							
	Driven	Driver	Driven	Driver	⅛ In.	¼ In.	⅜ In.	½ In.	⅝ In.	¾ In.	⅞ In.	1 In.	1¼ In.	1½ In.	1¾ In.	2 In.	2¼ In.	2½ In.	2¾ In.	3 In.	3¼ In.	3½ In.	3¾ In.	4 In.	4½ In.	5 In.	5½ In.	6 In.
2.50	27	45	20	48	8¾	17	25	32	38	43¼																		
2.78	20	45	30	48	8	15½	23	29½	35¼	40½	44¾																	
2.92	21	45	30	48	7½	15	21¾	28¼	34	39	43¼																	
3.24	27	33	19	48	6¾	13¼	19¾	25¾	31¼	36	40½	44¼																
3.70	27	33	19	42	6	11¾	17½	23	28	32½	36½	40½																
3.89	30	36	21	45	5½	11¼	16¾	22	26¾	31¼	35¼	39																
4.17	39	33	18	51	5¼	10½	15¾	20½	25¼	29½	33½	37	43¼															
4.46	39	36	21	51	4¾	9¾	14¾	19¼	23¾	27¾	31½	35	41½															
4.86	42	36	20	48	4½	9	13½	17¾	22	25¾	29½	33	39	44¼														
5.33	33	27	17	39	4	8¼	12¼	16½	20¼	23¾	27¼	30½	36½	44¼														
5.44	33	39	27	42	4	8	12	16	20	23½	26¾	30	36	41														
6.12	27	21	20	42	3½	7¼	11	14½	17¾	21	24¼	27	33	37¾	42													
6.22	33	24	19	42	3½	7	10¾	14¼	17½	20¾	23¾	26¾	32½	37¼	41½													
6.48	42	27	20	48	3¼	6¾	10¼	13½	16¾	20	23	25¾	31½	36¼	40¼	44¼												
6.67	30	36	.....	45	3¼	6½	10	13¼	16½	19½	22½	25¼	30¾	35¼	39½	43½												
7.29	45	27	21	48	3	6¼	9¼	12¼	15	18	20½	23½	28½	33	37	41	44¼											
7.41	51	30	17	39	3	6	9	12	14¾	17¾	20¼	22¾	28¼	32½	36½	40¼	43¾											
7.62	45	22	19	51	2¾	5¾	8¾	11½	14½	17¼	19¾	22¼	27½	32	36	39½	43											
8.33	30	39	.....	36	2½	5¼	8	10½	13¼	15¾	18¼	20½	25½	29½	33½	37	40½	43½										
8.95	48	33	24	39	2½	5	7½	10	12½	14¾	17	19¼	24	28	31¾	35¼	38½	41¼	44									
9.33	42	30	24	36	2¼	4¾	7¼	9½	11¾	14	16¼	18½	23	27	30½	34	37½	40¼	43									
9.52	33	24	27	39	2¼	4½	7	9¼	11½	13¾	16	18¼	22½	26½	30	33½	36½	39½	42¼	45								
10.29	39	20	19	36	2	4¼	6½	8¾	10¾	12¾	15	17¼	21	24¾	28¼	31½	34½	37½	40	42½	45							
10.37	42	27	24	36	2	4¼	6½	8½	10½	12¾	14¾	17	20¾	24½	28	31¼	34¼	37¼	39¾	42¼	44¾							
10.50	21	45	.....	20	2	4¼	6¼	8½	10½	12½	14½	16¾	20½	24¼	27¾	31	34	36¾	39½	42	44¼							
10.67	55	27	22	42	2	4	6¼	8¼	10¼	12¼	14¼	16½	20¼	24	27¼	30½	33½	36½	39	41½	43¾							
10.94	48	27	24	39	2	4	6	8¼	10¼	12	14	16¼	20	23½	26¾	30	33	35¾	38¼	40¾	43							
11.11	30	39	.....	27	2	4	6	8	10	11¾	13¾	16	19¾	23	26½	29½	32½	35¼	38	40¼	42½	44¾						
11.66	36	19	24	39	1¾	3¾	5¾	7½	9½	11¼	13¼	15¾	18¾	22	25¼	28½	31¼	34	36½	39	41¼	43½						
12.00	36	39	.....	30	1¾	3¾	5½	7¼	9¼	11	12¾	15	18¼	21½	24¾	27¾	30½	33¼	35¾	38	40¼	42½	44¾					
13.12	36	19	27	39	1½	3½	5¼	6¾	8½	10¼	11¾	13½	16¾	20	22¾	25¾	28¼	31	33¼	35¾	37¾	40	42	43¾				
13.33	48	33	.....	36	1½	3¼	5	6½	8¼	10	11½	13¼	16½	19½	22½	25½	28	30½	33	35¼	37½	39½	41½	43¼	46¾	49¼	52¼	
13.71	48	21	27	45	1½	3¼	4¾	6½	8	9¾	11¼	13	16	19	22	24¾	27¼	30	32¼	34½	36½	38¾	40¾	42½	45¾	49	51½	

Approximate Angle in Degrees for setting Milling Machine Table.

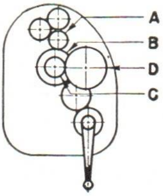
These tables are of special convenience for quickly setting the machine with proper change gears when the angle of spiral and the diameter of a piece of work are known. For example: To cut a drum cam 2″ diameter, 28° angle: Follow down the 2″ column to the nearest angle, 27¾, and the change gears are 36, 39, and 30.

See pages 61-63 for lead and angle formulae

TABLE OF CHANGE GEARS, APPROXIMATE ANGLES, AND ENGLISH LEADS FOR CUTTING SPIRALS—(Concluded)



Lead of Spiral Inches	A	B	C	D	DIAMETER OF WORK																									
	Driven	Driver	Driven	Driver	⅛ In.	¼ In.	⅜ In.	½ In.	⅝ In.	¾ In.	⅞ In.	1 In.	1¼ In.	1½ In.	1¾ In.	2 In.	2¼ In.	2½ In.	2¾ In.	3 In.	3¼ In.	3½ In.	3¾ In.	4 In.	4½ In.	5 In.	5½ In.	6 In.
15.24	45	17	19	33	1½	3	4½	5¾	7¼	8¾	10¼	11¾	14½	17¼	20	22½	25	27¼	29½	31¾	34	35¾	37¾	39½	42¾	46	48½	51
15.56	42	36	.....	27	1¼	2¾	4¼	5¾	7¼	8¾	10	11½	14¼	17	19½	22	24½	27	29	31¼	33¼	35¼	37	39	42¼	45¼	48	50½
15.75	42	24	27	30	1¼	2¾	4¼	5½	7	8½	9¾	11¼	14	16¾	19¼	21¾	24¼	26½	28¾	31	33	35	36¾	38½	42	45	47½	50
16.87	45	24	27	30	1¼	2½	4	5¼	6¾	7¾	9¼	10½	13¼	15¾	18¼	20½	22¾	25	27	29¼	31¼	33¼	35	36½	39¾	43	45¾	48¼
17.14	36	39	.....	21	1¼	2½	4	5¼	6½	7¾	9	10¼	13	15½	17¾	20¼	22¼	24¾	26¾	29	30¾	32¾	34½	36	39½	42½	45¼	47¾
18.75	45	36	.....	24	1	2¼	3½	4¾	6	7¼	8¼	9½	12	14¼	16¼	18½	20¾	22¾	25	26¾	28½	30¼	32	33¾	37	39¾	42¾	45
19.29	45	21	27	30	1	2¼	3½	4½	5¾	7	8	9¼	11½	13¾	16	18¼	20¼	22¼	24	26	28	29¾	31½	33	36¼	38¾	42	44½
19.59	48	21	36	42	1	2¼	3¼	4½	5¾	6¾	8	9¼	11½	13½	15¾	18	20	22	23¾	25¾	27½	29¼	31	32¾	35¾	38¾	41½	44
19.69	51	19	33	45	1	2¼	3¼	4½	5¾	6¾	8	9	11½	13½	15¾	17¾	20	21¾	23¾	25½	27½	29¼	31	32½	35¾	38½	41¼	43¾
21.43	45	36	.....	21	1	2	3¼	4¼	5¼	6¼	7½	8½	10½	12½	14½	16½	18½	20¼	22	23¾	25½	27¼	29	30¼	33½	36¼	38¾	41¼
22.50	45	36	.....	20	1	2	3	4	5	6	7	8	10	12	13¾	15¾	17½	19¼	21	22¾	24½	27	27¾	29¼	32¼	35	37½	40
23.33	42	36	.....	18	1	2	3	4	5	5¾	6¾	7¾	9¾	11½	13¼	15¼	17	18¾	20¼	22	23½	25¼	27	28¼	31¼	34	36¾	39
26.25	45	30	42	24	1	1¾	2¾	3½	4¼	5	6	7	8½	10¼	12	13½	15	16¾	18¼	19¾	21¼	22¾	24¼	25½	28¼	31	33¼	35¾
26.67	48	36	.....	18	¾	1¾	2¾	3½	4¼	5	6	6¾	8½	10	11¾	13¼	14¾	16½	18	19½	21	22¼	23¾	25¼	28	30½	33	35¼
28.00	48	30	42	24	¾	1¾	2½	3¼	4	4¾	5¾	6½	8	9½	11¼	12¾	14¼	15¾	17¼	18¾	20	21½	22¾	24	26¾	29¼	31¾	34
30.88	45	36	42	17	¾	1½	2¼	3	3¾	4½	5	5¾	7¼	8¾	10	11½	13	14¼	15½	17	18½	19½	21	22	26	27	29¼	31½
31.50	45	30	42	20	¾	1½	2¼	3	3½	4¼	5	5¾	7¼	8½	10	11¼	12¾	14	15¼	16½	18	19¼	20½	21¾	24¼	26½	28¾	31
36.00	51	30	36	17	½	1¼	2	2½	3¼	3¾	4½	5	6¼	7½	8¾	10	11	12¼	13½	14¾	16	17	18¼	19¼	21½	23½	25¾	27¾
41.14	48	21	36	20	½	1	1¾	2¼	2¾	3¼	4	4½	5½	6½	7¾	8¾	9¾	10¾	11¾	13	14	15	16	17	19	21	22¾	24½
45.00	55	22	36	20	½	1	1½	2	2½	3	3½	4	5	6	7	8	9	10	11	11¾	12¾	13¾	14¾	15½	17½	19¼	21	22¾
48.00	48	21	42	20	½	1	1½	2	2½	3	3¼	3¾	4¾	5½	6½	7½	8½	9¼	10¼	11¼	12	13	13¾	14½	16½	18	19¾	21½
51.43	48	21	45	20	½	¾	1½	1¾	2¼	2¾	3	3½	4½	5¼	6	7	7¾	8¾	9½	10½	11¼	12	12¾	13¾	14¾	17	18½	20
60.00	60	21	42	20	½	¾	1¼	1½	2	2¾	2½	3	3¾	4½	5¼	6	6¾	7½	8¼	9	9½	10¼	11	11¾	13¼	14¾	16	17½
63.00	51	20	42	17	¼	¾	1	1½	1¾	2¼	2½	2¾	3½	4¼	5	5¾	6½	7	7¾	8½	9¼	10	10½	11¼	12¾	14	15¼	16¾
65.00	60	20	39	18	¼	¾	1	1½	1¾	2	2½	2¾	3½	4¼	4¾	5½	6¼	7	7½	8¼	9	9½	10¼	11	12¼	13½	15	16¼
70.00	60	20	42	18	¼	¾	1	1¼	1½	2	2¼	2½	3¼	3¾	4½	5¼	5¾	6½	7	7¾	8¼	9	9½	10¼	11½	12¾	13¾	15
72.00	51	20	48	17	¼	½	1	1¼	1½	2	2¼	2½	3	3¾	4¼	5	5½	6¼	6¾	7½	8	8¾	9¼	10	11	12¼	13½	14¾
75.00	55	22	51	17	¼	½	1	1¼	1½	1¾	2	2½	3	3½	4¼	4¾	5½	6	6½	7¼	7¾	8¼	9	9½	10¾	11¾	13	14
80.00	51	18	48	17	¼	¼	¾	1¼	1½	1¾	2	2¼	2¾	3¼	4	4½	5	5½	6¼	6¾	7¼	7¾	8½	9	10½	11	12¼	13¼
85.00	60	18	51	20	¼	½	¾	1	1¼	1½	1¾	2	2¾	3¼	3¾	4¼	4¾	5¼	5¾	6¼	6¾	7¼	8	8½	9½	10½	11½	12½
90.00	60	17	51	20	¼	½	¾	1	1¼	1½	1¾	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	9	10	10¾	11¾
100.00	60	17	51	18	....	½	¾	1	1¼	1½	1½	1¾	2¼	2¾	3¼	3½	4	4½	5	5½	5¾	6¼	6¾	7¼	8	9	9¾	10¾
107.80	60	17	55	18	....	½	¾	¾	1	1¼	1½	1¾	2	2½	3	3¼	3¾	4¼	4½	5	5½	5¾	6¼	6¾	7½	8¼	9	10



ENGLISH LEADS AND CHANGE GEARS FOR MILLING SPIRAL END MILLS

Set Machine Table to Angle of Approximately 20 Degrees

Diameter of Mill, Inches	Lead in Inches	Driven A	Driver B	Driven C	Driver D
⅜	3.24	27	33	19	48
½	4.32	36	33	19	48
⅝	5.40	45	33	19	48
¾	6.48	42	27	20	48
⅞	7.56	42	22	19	48
1	8.64	42	27	20	36
1⅛	9.72	45	27	21	36
1¼	10.79	36	20	27	45
1⅜	11.87	36	21	27	39
1½	12.94	22	45	..	17
1¾	15.11	48	22	27	39
2	17.26	51	19	27	42
2¼	19.41	33	36	..	17
2½	21.58	51	20	33	39
2¾	23.73	55	17	22	30
3	25.88	55	17	36	45
3¼	28.05	51	30	33	20
3½	30.22	51	30	48	27
3¾	32.38	51	27	36	21
4	34.53	51	24	39	24

ENGLISH LEADS AND CHANGE GEARS FOR MILLING SPIRAL MILLING CUTTERS

Set Machine Table to Angle of Approximately 25 Degrees

Diameter of Mill, Inches	Lead in Inches	Driven A	Driver B	Driven C	Driver D
½	3.37	27	33	21	51
⅝	4.22	27	24	18	48
¾	5.05	30	33	20	36
⅞	5.89	33	36	27	42
1	6.74	39	27	21	45
1¼	8.42	48	19	17	51
1½	10.11	42	22	27	51
1¾	11.79	42	19	42	45
2	13.47	36	21	33	42
2¼	15.16	48	19	27	45
2½	16.84	48	19	30	45
2¾	18.53	42	17	36	48
3	20.20	60	27	30	33
3¼	21.90	48	19	39	45
3½	23.58	48	19	42	45
3¾	25.26	48	33	..	19
4	26.95	42	33	36	17
4¼	28.63	51	19	48	45
4½	30.32	48	30	36	19
4¾	32.00	48	21	42	30
5	33.69	45	33	42	17
5¼	35.37	48	30	42	19
5½	37.06	45	30	42	17
5¾	38.76	45	22	36	19
6	40.43	42	22	36	17

TABLE OF TANGENTS

(Natural Tangents at Intervals of ¼°)

Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent	Degrees	Tangent
0°	.0000	**13°**	.2309	**26°**	.4877	**39°**	.8098	**52°**	1.280	**65°**	2.145	**78°**	4.705
¼	.0044	13¼	.2355	26¼	.4931	39¼	.8170	52¼	1.292	65¼	2.169	78¼	4.808
½	.0087	13½	.2401	26½	.4986	39½	.8243	52½	1.303	65½	2.194	78½	4.915
¾	.0131	13¾	.2447	26¾	.5040	39¾	.8317	52¾	1.315	65¾	2.220	78¾	5.027
1°	.0175	**14°**	.2493	**27°**	.5095	**40°**	.8391	**53°**	1.327	**66°**	2.246	**79°**	5.145
1¼	.0218	14¼	.2540	27¼	.5150	40¼	.8466	53¼	1.339	66¼	2.273	79¼	5.267
1½	.0262	14½	.2586	27½	.5206	40½	.8541	53½	1.351	66½	2.300	79½	5.396
1¾	.0306	14¾	.2633	27¾	.5261	40¾	.8617	53¾	1.364	66¾	2.328	79¾	5.530
2°	.0349	**15°**	.2680	**28°**	.5317	**41°**	.8693	**54°**	1.376	**67°**	2.356	**80°**	5.671
2¼	.0393	15¼	.2726	28¼	.5373	41¼	.8770	54¼	1.389	67¼	2.385	80¼	5.820
2½	.0437	15½	.2773	28½	.5430	41½	.8847	54½	1.402	67½	2.414	80½	5.976
2¾	.0480	15¾	.2820	28¾	.5486	41¾	.8925	54¾	1.415	67¾	2.444	80¾	6.140
3°	.0524	**16°**	.2867	**29°**	.5543	**42°**	.9004	**55°**	1.428	**68°**	2.475	**81°**	6.314
3¼	.0568	16¼	.2915	29¼	.5600	42¼	.9083	55¼	1.442	68¼	2.507	81¼	6.497
3½	.0612	16½	.2962	29½	.5658	42½	.9163	55½	1.455	68½	2.539	81½	6.691
3¾	.0655	16¾	.3010	29¾	.5716	42¾	.9244	55¾	1.469	68¾	2.572	81¾	6.897
4°	.0699	**17°**	.3057	**30°**	.5774	**43°**	.9325	**56°**	1.483	**69°**	2.605	**82°**	7.115
4¼	.0743	17¼	.3105	30¼	.5832	43¼	.9407	56¼	1.497	69¼	2.639	82¼	7.348
4½	.0787	17½	.3153	30½	.5890	43½	.9490	56½	1.511	69½	2.675	82½	7.596
4¾	.0831	17¾	.3201	30¾	.5949	43¾	.9573	56¾	1.525	69¾	2.711	82¾	7.861
5°	.0875	**18°**	.3249	**31°**	.6009	**44°**	.9657	**57°**	1.540	**70°**	2.748	**83°**	8.144
5¼	.0919	18¼	.3298	31¼	.6068	44¼	.9742	57¼	1.555	70¼	2.785	83¼	8.449
5½	.0963	18½	.3346	31½	.6128	44½	.9827	57½	1.570	70½	2.824	83½	8.777
5¾	.1007	18¾	.3395	31¾	.6188	44¾	.9913	57¾	1.585	70¾	2.864	83¾	9.131
6°	.1051	**19°**	.3443	**32°**	.6249	**45°**	1.000	**58°**	1.600	**71°**	2.904	**84°**	9.514
6¼	.1095	19¼	.3492	32¼	.6310	45¼	1.009	58¼	1.616	71¼	2.946	84¼	9.931
6½	.1139	19½	.3541	32½	.6371	45½	1.018	58½	1.632	71½	2.989	84½	10.385
6¾	.1184	19¾	.3590	32¾	.6432	45¾	1.027	58¾	1.648	71¾	3.033	84¾	10.883
7°	.1228	**20°**	.3640	**33°**	.6494	**46°**	1.036	**59°**	1.664	**72°**	3.078	**85°**	11.430
7¼	.1272	20¼	.3689	33¼	.6556	46¼	1.045	59¼	1.681	72¼	3.124	85¼	12.035
7½	.1317	20½	.3739	33½	.6619	46½	1.054	59½	1.698	72½	3.172	85½	12.706
7¾	.1361	20¾	.3789	33¾	.6682	46¾	1.063	59¾	1.715	72¾	3.221	85¾	13.457
8°	.1405	**21°**	.3839	**34°**	.6745	**47°**	1.072	**60°**	1.732	**73°**	3.271	**86°**	14.301
8¼	.1450	21¼	.3889	34¼	.6809	47¼	1.082	60¼	1.750	73¼	3.323	86¼	15.257
8½	.1495	21½	.3939	34½	.6873	47½	1.091	60½	1.768	73½	3.376	86½	16.350
8¾	.1539	21¾	.3990	34¾	.6937	47¾	1.101	60¾	1.786	73¾	3.431	86¾	17.610
9°	.1584	**22°**	.4040	**35°**	.7002	**48°**	1.111	**61°**	1.804	**74°**	3.487	**87°**	19.081
9¼	.1629	22¼	.4091	35¼	.7067	48¼	1.120	61¼	1.823	74¼	3.546	87¼	20.819
9½	.1673	22½	.4142	35½	.7133	48½	1.130	61½	1.842	74½	3.606	87½	22.904
9¾	.1718	22¾	.4193	35¾	.7199	48¾	1.140	61¾	1.861	74¾	3.668	87¾	24.452
10°	.1763	**23°**	.4245	**36°**	.7265	**49°**	1.150	**62°**	1.881	**75°**	3.732	**88°**	28.636
10¼	.1808	23¼	.4296	36¼	.7332	49¼	1.161	62¼	1.901	75¼	3.798	88¼	32.730
10½	.1853	23½	.4348	36½	.7400	49½	1.171	62½	1.921	75½	3.867	88½	38.188
10¾	.1899	23¾	.4400	36¾	.7467	49¾	1.181	62¾	1.942	75¾	3.938	88¾	45.829
11°	.1944	**24°**	.4452	**37°**	.7536	**50°**	1.192	**63°**	1.963	**76°**	4.011	**89°**	57.29
11¼	.1989	24¼	.4505	37¼	.7604	50¼	1.202	63¼	1.984	76¼	4.087	89¼	76.39
11½	.2035	24½	.4557	37½	.7673	50½	1.213	63½	2.006	76½	4.165	89½	114.59
11¾	.2080	24¾	.4610	37¾	.7743	50¾	1.224	63¾	2.028	76¾	4.247	89¾	229.17
12°	.2126	**25°**	.4663	**38°**	.7813	**51°**	1.235	**64°**	2.050	**77°**	4.332	**90°**	
12¼	.2171	25¼	.4716	38¼	.7883	51¼	1.246	64¼	2.073	77¼	4.419		
12½	.2217	25½	.4770	38½	.7954	51½	1.257	64½	2.097	77½	4.511		
12¾	.2263	25¾	.4823	38¾	.8026	51¾	1.269	64¾	2.120	77¾	4.606		

ORDERING REPAIR PARTS

You will receive quicker service when ordering repair parts if you will adhere to the following procedure:

1. **State amount wanted.**
2. **Give part number and name or description of part, and where obtained.**
    - (*a*) Parts catalog.
    - (*b*) Parts number stamped on part.
    - (*c*) Prior invoice.
3. **Give complete serial number of machine.** The serial number will be found stamped in two places: Horizontal Machines, on the face of the column near the spindle, and front of the table near the right hand end. Vertical Machines, top of the scraped bearing for the knee and front of the table near the right hand end.
4. **Specify each individual piece required.** If only certain parts of a unit are required, never use the word "complete"; it always raises the question as to how much of the unit to supply. In some cases, due to the nature of the parts, it will be less costly to you for us to supply additional related pieces, especially if part wanted is obsolete.
5. **Specify how and where to ship.** Do not say "Ship quickest way". Be definite and state the agency desired, that is:—Air Mail, Parcel Post, Special Delivery, Express, Motor Freight, Rail Freight, etc.

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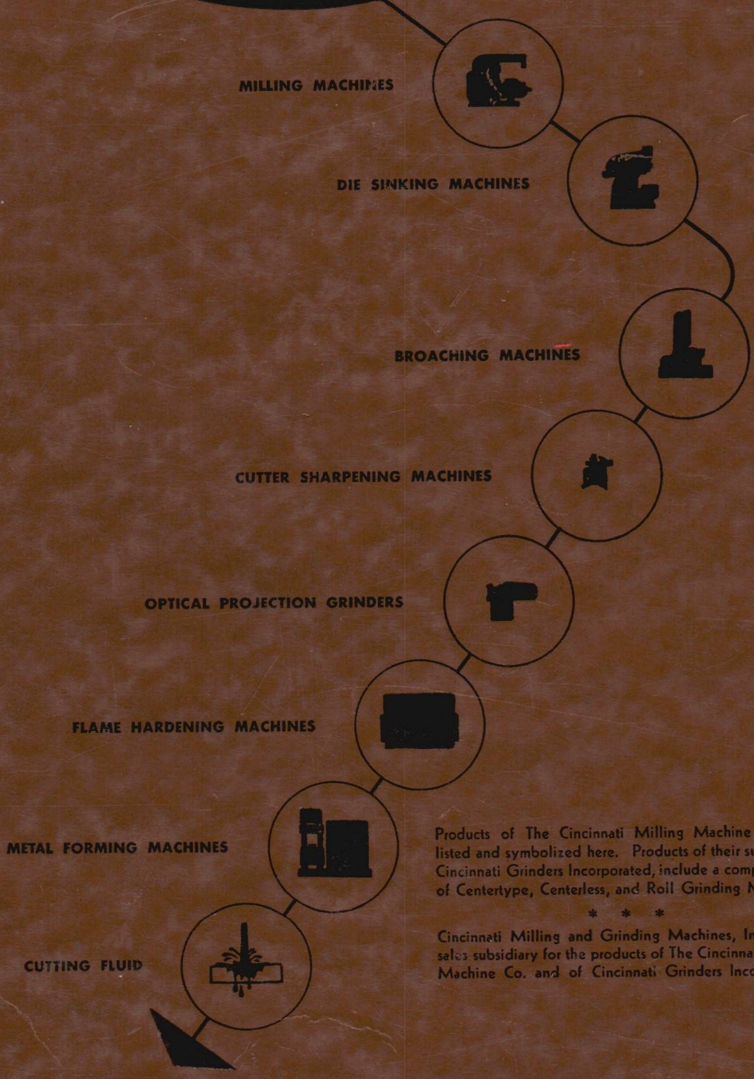

Products of The Cincinnati Milling Machine Co. are listed and symbolized here. Products of their subsidiary, Cincinnati Grinders Incorporated, include a complete line of Centertype, Centerless, and Roll Grinding Machines.

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